Category 1

Ecology-Approved BMPs Not in the HRM

For instructions on seeking approval to use these BMPs, refer to Section 5-3.6, Seeking Authorization for Alternative BMP Options, in Chapter 5 of the *Highway Runoff Manual* (HRM). All BMPs referenced in Category 1, which are not included herein, can be found in Chapter 5, Section 5-4, of the HRM.

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Category 1
Ecology-Approved BMPs Not in the HRM

1 Vault-Type BMPs

WSDOT does not recognize this BMP as a viable highway application for basic treatment due to cost and performance considerations associated with maintaining this treatment option. For instructions on seeking approval for using this BMP, refer to Section 5-3.6, Seeking Authorization for Alternative BMP Options, in Chapter 5 of the Highway Runoff Manual.

BMP RT.19 Wet Vault

Introduction

General Description

Wet vaults are underground structures similar in appearance to detention vaults (see BMP FC.04), except wet vaults have permanent pools of water in the bottom that dissipate flow energy and improve the settling of particulate pollutants (see Figure RT.19.1). Being underground, wet vaults lack the biological pollutant-removal mechanisms, such as soil microbial activity and algae uptake, present in surface wet ponds (see BMP RT.12 in the HRM).

Applications and Limitations

Wet vaults may be used for roadway projects if space limitations preclude the use of other treatment BMPs. However, they are most practical in relatively small catchments (less than 10 acres of impervious surface) with high land values because vaults are relatively expensive. Combined wet/detention vaults (see BMP CO.03) are typically considered in similar situations.

A wet vault is believed to be ineffective in removing dissolved pollutants such as soluble phosphorus or metals such as copper. Declining oxygen levels are also a concern, especially in warm summer months, because of limited contact with air and wind. However, the extent to which this potential problem occurs has not been documented.

Belowground structures like wet vaults are relatively difficult and expensive to maintain. The need for maintenance is not often recognized and as a result maintenance is often neglected.

Design Flow Elements

Flows to Be Treated

The flows to be treated by wet vaults are the same as those for wet ponds (see BMP RT.12 in the HRM).

Outlet Control Structure

The outlet pipe must be backsloped or have a tee section, the lower arm of which should extend 1 foot below the runoff treatment design water surface to trap oils and floatables in the vault.

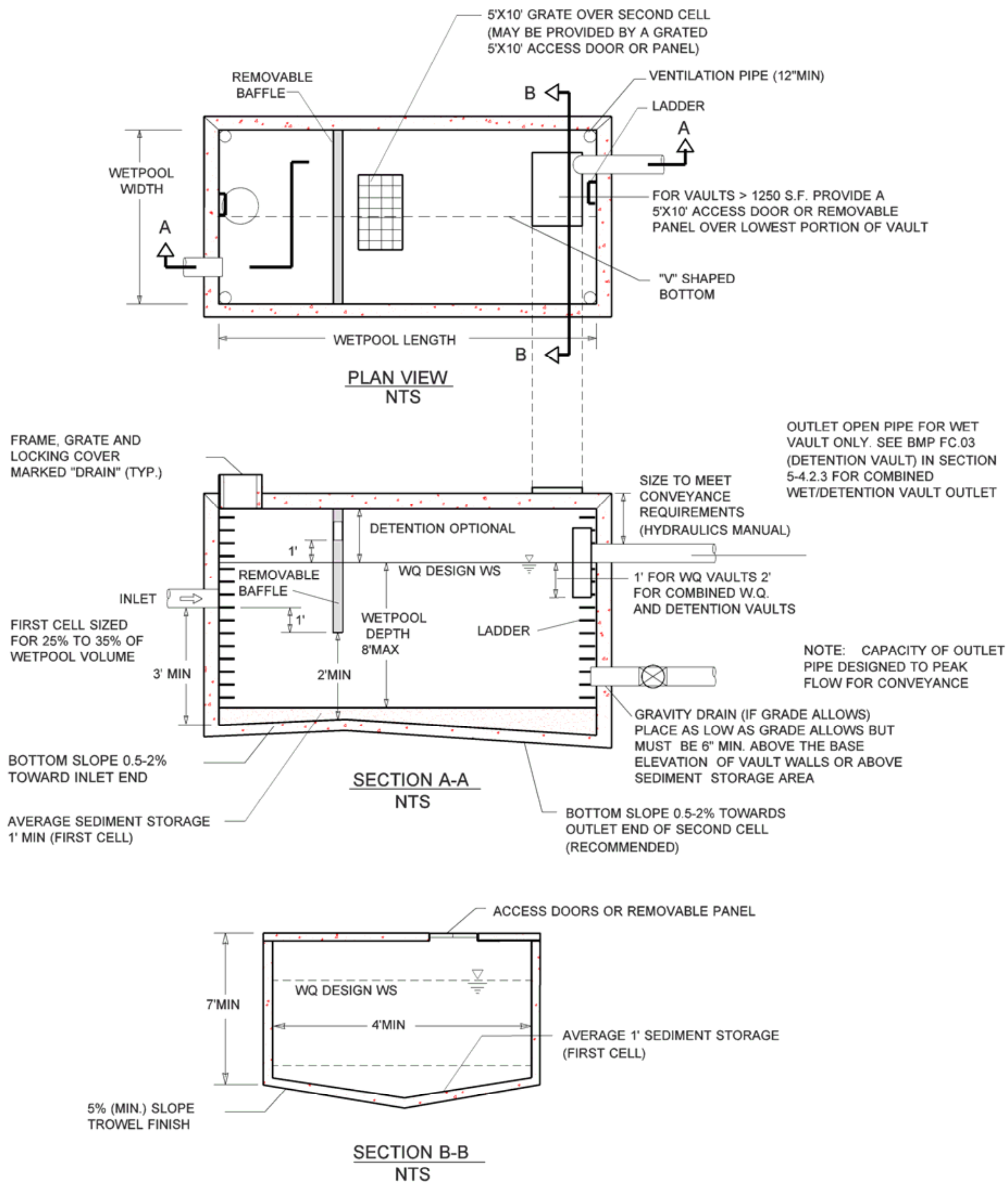


Figure RT.19.1. Wet vault.

Overflow or Bypass

The capacity of the outlet pipe and available head above the outlet pipe must be designed to pass the 100-year peak design flow for developed site conditions without exceeding the head space within the vault (see Chapter 4 of the HRM for hydrologic methods). The available headspace above the outlet pipe must be a minimum of 6 inches. Provisions should be made to maintain the passage of flows should the outlet plug.

Structural Design Considerations

Geometry

Sizing Procedure

Wet vault sizing procedures are the same as those for wet ponds (see BMP RT.12 in the HRM), except for the following modifications:

- The sediment storage depth in the first cell must average 1 foot. Because of the V-shaped bottom, the depth of sediment storage needed above the bottom of the side wall is roughly proportional to vault width according to the following schedule:

Vault Width (feet)	Sediment Depth (inches from bottom of the side wall)
15	10
20	9
40	6
60	4

- The second cell must be a minimum of 3 feet deep because planting cannot be used to prevent resuspension of sediment in shallow water as it can in open ponds.
- A flow length-to-width ratio greater than 3:1 is desirable.
- The inlet to the wet vault must be submerged, with the inlet pipe invert a minimum of 3 feet from the vault bottom (not including sediment storage). The top of the inlet pipe should be submerged at least 1 foot, if possible.
- The number of inlets to the wet vault should be limited, and the flow path length should be maximized from inlet to outlet (e.g., locate the inlet and outlet in opposing corners of the vault).
- A gravity drain for maintenance must be provided if grade allows.
- The gravity drain should be as low as the site situation allows; however, the invert must be no lower than the average sediment storage depth. At a minimum, the invert must be 6 inches above the base elevation of the vault sidewalls.
- The drain must be 8 inches (minimum) in diameter and controlled by a valve. Use of a shear gate is allowed only at the inlet end of a pipe located within an approved structure.

- Operational access to the valve must be provided at the finished ground surface. The valve location must be accessible and well marked, with at least 1 foot of paving placed radially around the box. The valve must also be protected from damage and unauthorized operation.
- If not located in the vault, a valve box without an access manhole is allowed to a maximum depth of 5 feet. If the valve box is more than 5 feet deep, an access manhole is required.

Note: If a vault is over 20 feet in width, then it must be designed by the Headquarters (HQ) Bridge and Structures Office, and added to the bridge inspection inventory by the Preservation Section.

Materials

Wet vaults must conform to the materials and structural stability criteria specified for detention vaults (see BMP FC.04).

Wet vaults may be constructed using alternative materials, such as arch culvert sections or large corrugated metal pipe, provided the top area at the runoff treatment design water surface is, at a minimum, equal to that of a vault with vertical walls designed with an average depth of 6 feet. If alternative materials are used to construct a wet vault, all seams and gaps must be sealed so that water does not leak out of the wet pool.

Where pipes enter and leave the vault below the runoff treatment design water surface, they must be sealed using a nonporous, nonshrinking grout.

Berms, Baffles, and Slopes

If a removable baffle is used to separate the two wet vault cells, the following criteria apply:

- The baffle must extend from a minimum of 1 foot above the runoff treatment design surface to a minimum of 1 foot below the invert elevation of the inlet pipe.
- The lowest point of the baffle must be a minimum of 2 feet from the bottom of the vault, and greater if feasible.

If the vault storage volume is less than 2,000 cubic feet (inside dimensions), or if the length-to-width ratio of the vault pool is 5:1 or greater, the baffle wall may be omitted and the vault may be one-celled.

The two cells of a wet vault should not be divided into additional subcells by internal walls. If internal structural support is needed, post-and-pier construction (rather than walls) is preferred to support the vault lid. Any walls used within cells must be positioned to lengthen, rather than divide, the flow path.

The bottom of the first cell must be sloped toward the inlet. Slope should be between 0.5% (minimum) and 2% (maximum). The second cell may be level (longitudinally), sloped toward the outlet, with a high point between the first and second cells.

The vault bottom must slope laterally a minimum of 5% from each side toward the center, forming a broad V to facilitate sediment removal. (Note that more than one V may be used to minimize vault depth.)

Exception: The vault bottom may be flat if removable panels are provided over the entire vault. Removable panels must be at grade, have stainless steel lifting eyes, and weigh no more than five tons per panel.

The highest point of the vault bottom must be at least 6 inches below the outlet elevation to provide for sediment storage over the entire bottom.

Site Design Elements

Setback Requirements

The following setback criteria apply to wet vaults:

- Wet vaults must be a minimum of 5 feet from any property line or vegetative buffer. This distance may need to be increased based on permit requirements of the local jurisdiction.
- Wet vaults must be a minimum of 20 feet from any septic tank or drain field.
- The designer should request from the WSDOT Materials Laboratory a geotechnical report for the project that evaluates any potential structural site instability due to extended subgrade saturation and/or head loading of the permeable layer, including the potential impacts to downgradient properties, especially on hills with known side-hill seeps. The report should address the adequacy of the proposed wet vault location and recommend the necessary setbacks from any steep slopes and building foundations.

General Maintenance Requirements

General maintenance criteria for wet vaults are the same as those for detention vaults (see BMP FC.04), except for the following:

- A minimum of 50 square feet of grate must be provided over the second cell. If the surface area of the second cell is greater than 1,250 square feet, 4% (minimum) of the top must be grated. This requirement may be met by one grate or by many smaller grates distributed over the second cell area. (Note that a grated access door can be used to meet this requirement.)
- Lockable grates instead of solid manhole covers are recommended to increase air contact with the wet pool. (Note that underground vaults with stagnant water make prime habitat for mosquito larvae. Grated covers allow easy access by adult mosquitoes. From a vector control aspect, solid covers are preferred. Wet vaults designed as oil/water separators could potentially trap enough oil to create lethal conditions for mosquito larvae.)

BMP CO.03 Combined Wet/Detention Vault

WSDOT does not recognize this BMP as a viable highway application for combined basic treatment/ flow control due to cost and performance considerations associated with maintaining this treatment option. For instructions on seeking approval for using this BMP, refer to Section 5-3.6, Seeking Authorization for Alternative BMP Options, in Chapter 5 of the Highway Runoff Manual.

Introduction

General Description

Combined wet/detention vaults have the appearance of detention vaults (see BMP FC.04), but contain a permanent pool of water in the bottom for runoff treatment. The following design procedures, requirements, and recommendations cover differences in the design of the stand-alone wet vault (see BMP RT.19) combined with detention storage.

Applications and Limitations

Combined wet/detention vaults are very efficient for sites where space limitations preclude the use of surface runoff treatment and flow control facilities. The runoff treatment facility may often be placed beneath the detention facility without increasing the facility surface area.

The basis for pollutant removal in a combined wet/detention vault is the same as that for the stand-alone wet vault (see BMP RT.19). However, in the combined facility, the detention function creates fluctuating water levels and added turbulence. For simplicity, the positive effect of the extra live storage volume and the negative effect of increased turbulence are assumed to balance (and are thus ignored) when sizing the wet pool volume.

Design Flow Elements

Flows to Be Treated

Flows to be treated by a combined wet/detention vault are the same as those for wet vaults (see BMP RT.19) and detention vaults (see BMP FC.04).

Overflow or Bypass

Overflow must be provided as described in BMP FC.04, Detention Vault.

Outlet Control Structure

Outlet control structures must be designed as specified in BMP FC.03 of the HRM.

Structural Design Considerations

Geometry

The methods of analysis for combined wet/detention vaults are identical to those outlined for wet vaults (see BMP RT.19) and for detention facilities. The wet vault volume for a combined facility must be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event.

The procedure specified in BMP FC.04, Detention Vault, is used to size the detention portion of the vault.

The design criteria for detention vaults (see BMP FC.04) and wet vaults (see BMP RT.19) must both be met, except for the following modifications or clarifications**:**

- The minimum sediment storage depth in the first cell must average 1 foot. The 6 inches of sediment storage required for detention vaults do not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with detention vault sediment storage requirements.
- The oil-retaining baffle must extend a minimum of 2 feet below the runoff treatment design surface.

  Intent: The greater depth of the baffle in relation to the runoff treatment design water surface compensates for the greater water level fluctuations in the combined wet/detention vault. The greater depth is deemed prudent to better ensure that separated oils remain within the vault, even during storm events.

Note: If a vault is over 20 feet in width, then it must be designed by the HQ Bridge and Structures Office, and added to the bridge inspection inventory by the Preservation Section.

Materials

Combined wet/detention vaults must conform to the materials and structural stability criteria specified for detention vaults (see BMP FC.04).

Where pipes enter and leave the vault below the runoff treatment design water surface, they must be sealed using a nonporous, nonshrinking grout.

Galvanized materials should be avoided whenever possible because they can leach zinc into the environment.

Berms, Baffles, and Slopes

Criteria for vault baffles are the same as those for wet vaults (see BMP RT.19).

Groundwater Issues

Live storage requirements are the same as for detention ponds (see BMP FC.03 in the HRM). This does not apply to the wet vault dead storage component.

Site Design Elements

Setback Requirements

Setback requirements are the same as those for wet vaults (see BMP RT.19).

Right-of-Way

Right-of-way requirements for wet/detention vaults are the same as those for detention vaults (see BMP FC.04).

General Maintenance Requirements

General maintenance criteria are the same as those for wet vaults (see BMP RT.19).

BMP FC.04 Detention Vault

> *WSDOT does not recognize this BMP as a viable highway application for flow control due to cost and performance considerations associated with maintaining this treatment option. For instructions on seeking approval for using this BMP, refer to Section 5-3.6, Seeking Authorization for Alternative BMP Options, in Chapter 5 of the Highway Runoff Manual.*

Introduction

General Description

Detention vaults are box-shaped underground storage facilities, typically constructed with reinforced concrete, that provide live storage volume to enable reduction of stormwater runoff flow rates and matching of predeveloped flow durations discharged from a project site, where necessary (see Figure FC.04.1). Detention vaults are commonly used for flow control when infiltration is infeasible and space is not available for surface detention facilities. Detention vaults are designed to drain completely after a storm event so that the live storage volume is available for the next event.

Applications and Limitations

Detention vaults are commonly used for projects that have limited space and thus have no room for a pond. Detention tanks (see BMP FC.05) are a similar option for these situations. Although underground facilities are appealing because of their minimal right-of-way requirements, they do not function as well as ponds.

Vaults are difficult to maintain due to poor accessibility and reduced ability to determine when maintenance is necessary. Typically, the increased construction and maintenance expenses offset any initial cost benefits derived from smaller right-of-way purchases. As a result, underground detention facilities are the least preferred method of flow control. To ensure that detention vaults are used only when absolutely necessary, the HQ Hydraulics Office must approve their use.

Detention vaults may be designed as flow-through systems with bottoms level (longitudinally) or sloped toward the inlet to facilitate sediment removal. The distance between the inlet and outlet should be maximized (as feasible). Detention vaults can be constructed to include dead storage in the bottom for runoff treatment, analogous to surface pond systems (see BMP CO.01 in the HRM).

Design Flow Elements

Flows to Be Detained

The volume and outflow design for detention vaults must be in accordance with flow control criteria presented in Section 3-3.6 in Chapter 3 of the HRM, under Minimum Requirement 6. Hydrologic analysis and design methods are presented in Sections 4-3 and 4-4 in Chapter 4 of the HRM. Note that the design water surface elevation is the highest water surface elevation that is projected in order to satisfy the outflow criteria.

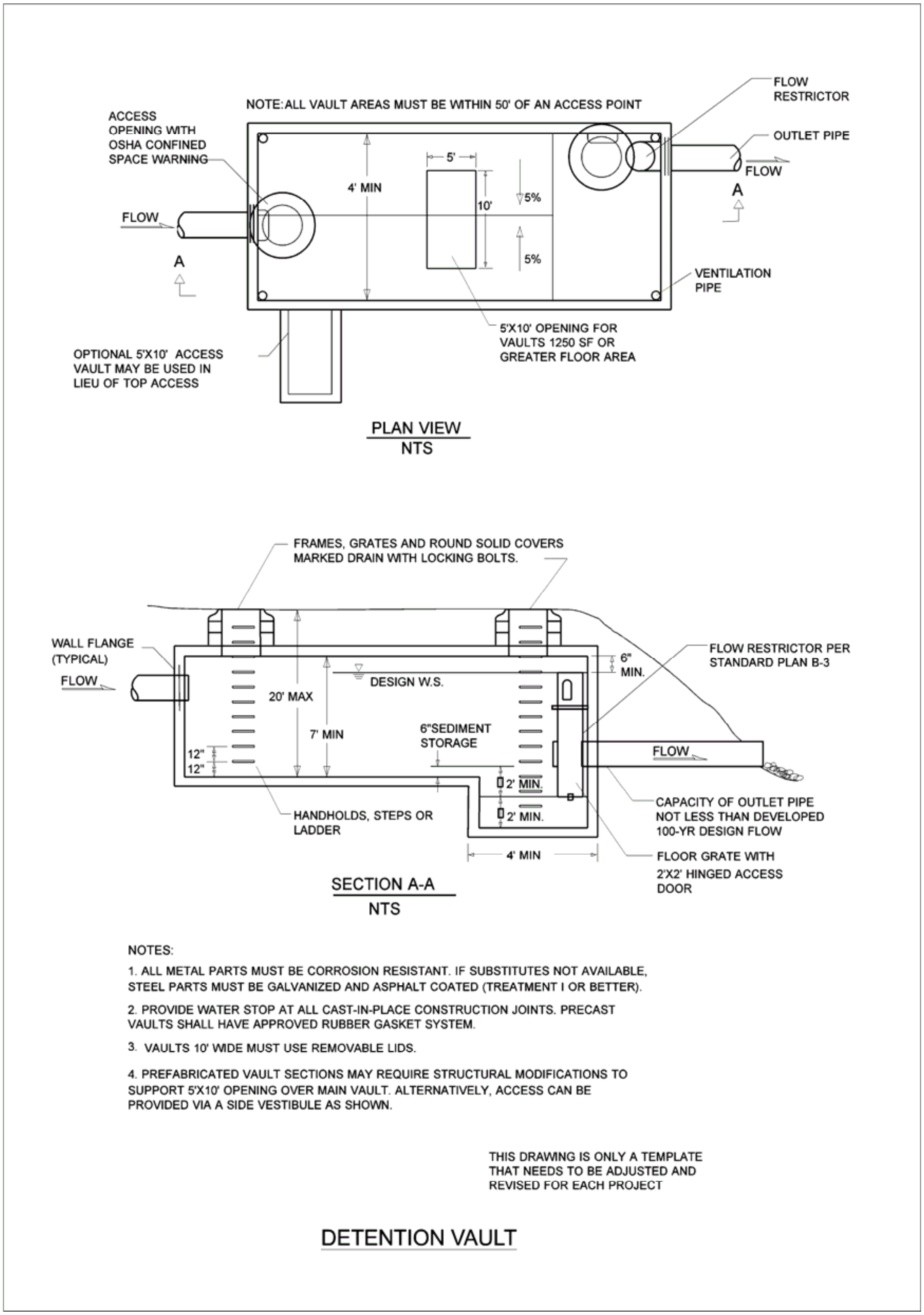


Figure FC.04.1. Detention vault.

Overflow or Bypass

A primary overflow (usually a riser pipe within the control structure; see BMP FC.03 in the HRM) must be provided to bypass the 100-year postdeveloped peak flow over or around the flow restrictor system.

Outlet Control Structure

Outlet control structures must be designed as specified in BMP FC.03, Detention Pond, in the HRM.

Structural Design Considerations

Geometry

Detention vaults may be designed with bottoms level (longitudinally) or sloped toward the inlet to facilitate sediment removal. The distance between the inlet and outlet should be maximized (as feasible).

The detention vault bottom may slope at least 5% from each side toward the center, forming a broad V to facilitate sediment removal. More than one V may be used to minimize vault depth. However, the vault bottom may be flat with a minimum of 6 inches of sediment storage if removable panels are provided over the entire vault. It is recommended that the removable panels be at grade, have stainless steel lifting eyes, and weigh no more than five tons per panel.

The invert elevation of the outlet should be elevated above the bottom of the vault to provide an average 6 inches (or greater) of sediment storage over the entire bottom. The outlet should also be elevated a minimum of 2 feet above the orifice to retain oil within the vault. To accomplish this, a sump can be constructed in the vicinity of the outlet (see Figure FC.04.1).

For maintenance access, the maximum depth from finished grade to the vault invert should be 20 feet. The minimum internal height should be 7 feet from the highest point of the vault floor (not sump), and the minimum width should be 4 feet. The minimum internal height requirement may not be needed for any areas covered by removable panels.

Note: If a vault is over 20 feet in width, then it must be designed by the HQ Bridge and Structures Office, and added to the bridge inspection inventory by the Preservation Section.

Materials

Minimum 3,000-psi structural reinforced concrete may be used for detention vaults. All construction joints must be provided with water stops.

All vaults must meet structural requirements for overburden support and H-20 traffic loading (see the WSDOT Standard Specifications). Vaults located under roadways must meet any live load requirements of the local jurisdiction. Cast-in-place wall sections must be designed as retaining walls. A licensed civil engineer with structural expertise must stamp structural designs for cast-in-place vaults. Vaults must be placed on stable, well-consolidated native material with suitable bedding per the WSDOT Standard Specifications. Vaults must not be placed in fill slopes unless the slopes have been analyzed in a geotechnical report for stability and constructibility.

Groundwater Issues

Criteria are the same as for detention ponds (see BMP FC.03 in the HRM).

Site Design Elements

Setback Requirements

Detention vaults must be a minimum of 5 feet from any property line or vegetative buffer. This distance may need to be increased based on the permit requirements of the local jurisdiction.

Detention vaults must be 100 feet from any septic tank or drain field (except wet vaults, which must be a minimum of 20 feet).

The designer should request from the WSDOT Materials Laboratory a geotechnical report for the project that evaluates any potential structural site instability due to extended subgrade saturation and/or head loading of the permeable layer, including the potential impacts to downgradient properties (especially on hills with known side-hill seeps). The report should address the adequacy of the proposed detention vault locations and recommend the necessary setbacks from any steep slopes and building foundations.

General Maintenance Requirements

For general maintenance requirements, see Section 5.

BMP FC.05 Detention Tank

WSDOT does not recognize this BMP as a viable highway application for flow control due to cost and performance considerations associated with maintaining this treatment option. For instructions on seeking approval for using this BMP, refer to Section 5-3.6, Seeking Authorization for Alternative BMP Options, in Chapter 5 of the Highway Runoff Manual.

Introduction

General Description

Detention tanks are underground storage facilities, typically constructed with large-diameter corrugated metal pipe, that provide live storage volume to enable reduction of stormwater runoff flow rates and matching of predeveloped flow durations discharged from a project site (see Figure FC.05.1). Detention tanks are commonly used for flow control where infiltration is infeasible and space is not available for surface detention facilities and where costs may be lower compared to an underground detention vault (see BMP FC.04). Detention tanks are designed to drain completely after a storm event so that the live storage volume is available for the next event.

Applications and Limitations

Detention tanks are commonly used for projects that have limited space and thus have no room for a pond. Although underground facilities are appealing because of their minimal right-of-way requirements, they do not function as well as ponds.

Tanks are difficult to maintain due to poor accessibility and the reduced ability to determine when maintenance is necessary. Typically, the increased construction and maintenance expenses offset any initial cost benefits derived from smaller right-of-way purchases. As a result, underground detention facilities are the least preferred method of flow control. To ensure that detention tanks are used only when absolutely necessary, the HQ Hydraulics Office must approve their use.

Detention tanks may be designed as flow-through systems with manholes in line to promote sediment removal and facilitate maintenance. Tanks may also be designed as backup systems if preceded by runoff treatment facilities because little sediment should reach the inlet/control structure and low head losses can be expected because of the proximity of the inlet/control structure to the tank (see optional parallel tank in Figure FC.05.1).

Design Flow Elements

Flows to Be Detained

The volume and outflow design for detention tanks must be in accordance with flow control criteria presented in Section 3-3.6 in Chapter 3 of the HRM, under Minimum Requirement 6. Hydrologic analysis and design methods are presented in Sections 4-3 and 4-4 in Chapter 4 of the HRM.

Note: The design water surface elevation is the highest water surface elevation that is projected in order to satisfy the outflow criteria.

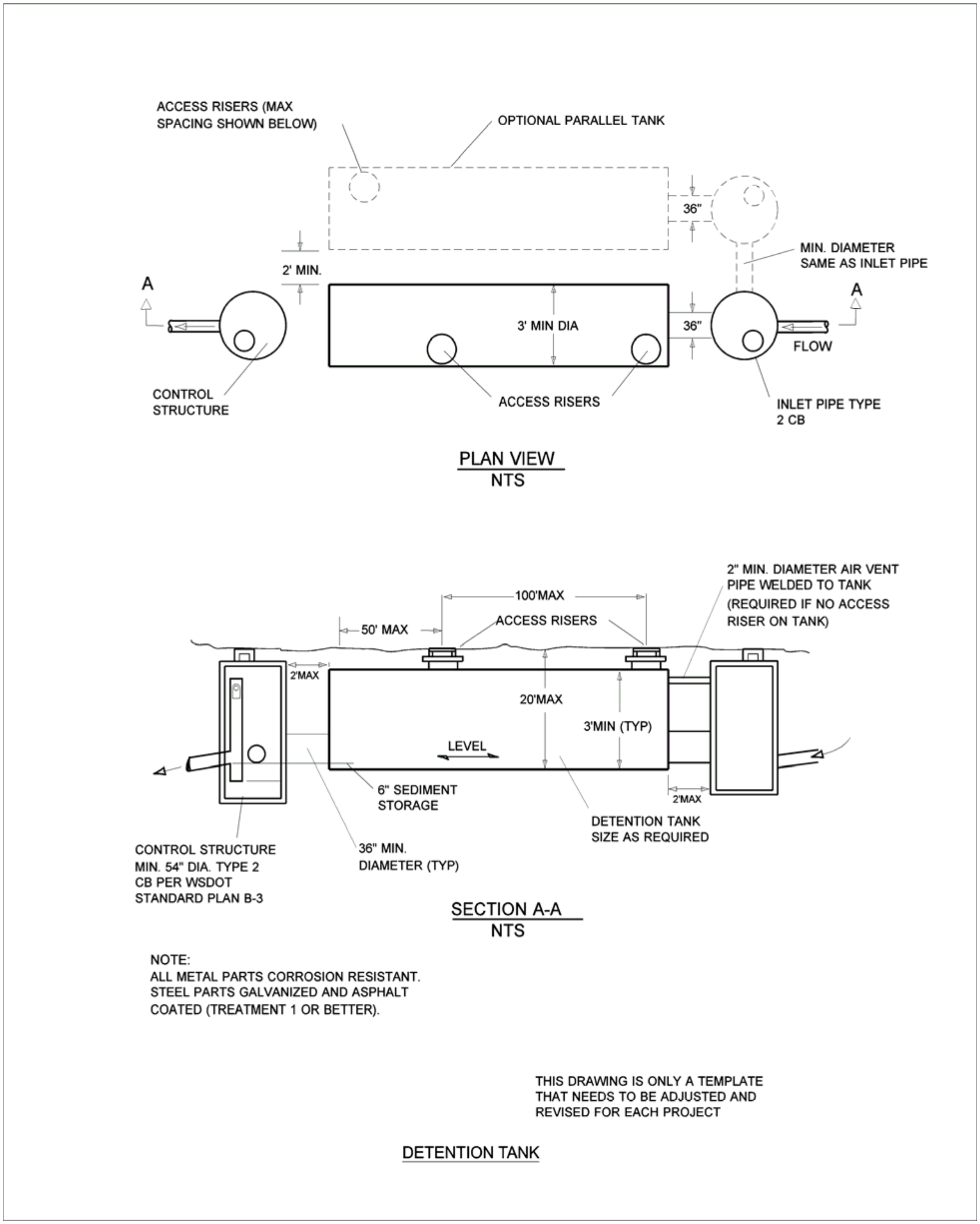


Figure FC.05.1. Detention tank.

Overflow or Bypass

A primary overflow (usually a riser pipe within the control structure; see BMP FC.03 in the HRM) must be provided to bypass the 100-year postdeveloped peak flow over or around the flow restrictor system.

Outlet Control Structure

Outlet control structures must be designed as specified in BMP FC.03 in the HRM.

Structural Design Considerations

Geometry

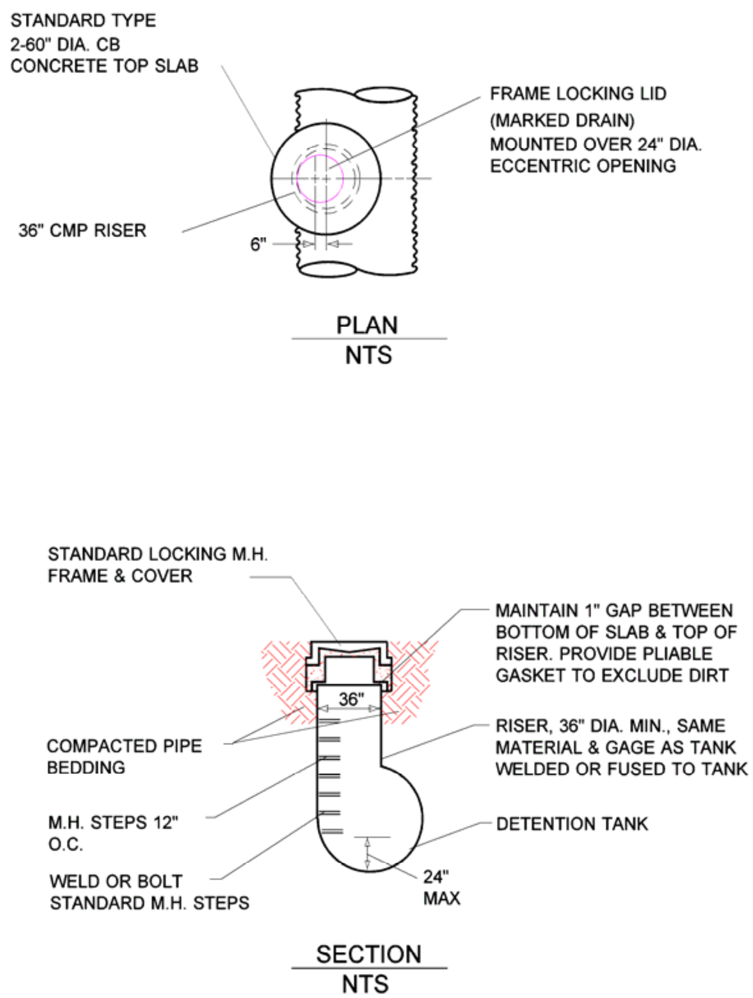
- The detention tank bottom should be located 6 inches below the inlet and outlet to provide dead storage for sediment.
- The minimum pipe diameter for a detention tank is 36 inches.
- Tanks larger than 36 inches in diameter may be connected to adjoining tanks in a manifold arrangement with a short section (2-foot maximum length) of 36-inch-minimum-diameter pipe.
- For maintenance access, the maximum depth from finished grade to the tank invert should be 20 feet.

  Note: Control structures and access risers should have additional ladder rungs to allow ready access to all tank inlet and outlet pipes, regardless of water level (see Figures FC.05.1 and FC.05.2).
- In moderately pervious soils where seasonal groundwater may induce flotation, buoyancy tendencies must be balanced either by ballasting with backfill or concrete backfill, providing concrete anchors, increasing the total weight, or providing subsurface drains to permanently lower the groundwater table. Calculations that demonstrate stability must be documented.

Materials

Galvanized metals leach zinc into the environment, especially in standing water situations. Leaching can result in zinc concentrations toxic to aquatic life. Therefore, use of galvanized materials in stormwater facilities and conveyance systems is discouraged. Where other metals, such as aluminum, stainless steel, or plastics are available, they should be used.

Pipe material, joints, and protective treatment for tanks should be in accordance with Section 9.05 of the WSDOT Standard Specifications.



NOTES:

1. USE ADJUSTING BLOCKS AS REQUIRED TO BRING FRAME TO GRADE.
2. ALL MATERIALS TO BE ALUMINUM OR GALVANIZED AND ASPHALT COATED (TREATMENT 1 OR BETTER).
3. MUST BE LOCATED FOR ACCESS BY MAINTENANCE VEHICLES.
4. MAY SUBSTITUTE WSDOT SPECIAL TYPE IV MANHOLE (RCP ONLY).

THIS DRAWING IS ONLY A TEMPLATE
THAT NEEDS TO BE ADJUSTED AND
REVISED FOR EACH PROJECT

DETENTION TANK ACCESS RISER DETAIL

Figure FC.05.2. Detention tank access riser detail.

Tanks must meet structural requirements for overburden support and traffic loading, if appropriate. H-20 live traffic loads must be accommodated for tanks lying under parking areas and access roads. Metal tank end plates must be designed for structural stability at maximum hydrostatic loading conditions. Flat end plates generally require thicker-gage material than the pipe or require reinforcing ribs. Tanks must be placed on stable, well-consolidated native material with suitable bedding. Tanks must not be placed in fill slopes unless the slopes have been analyzed in a geotechnical report for stability and constructibility.

Note: If a tank is over 20 feet in width, then it must be designed by the HQ Bridge and Structures Office, and added to the bridge inspection inventory by the Preservation Section.

Groundwater Issues

Criteria are the same as for detention ponds (see BMP FC.03 in the HRM).

Site Design Elements

Setback Requirements

Detention tanks must be a minimum of 5 feet from any property line or vegetative buffer. This distance may need to be increased based on the permit requirements of the local jurisdiction.

Detention tanks must be 100 feet from any septic tank and drain field (except wet vaults, which must be a minimum of 20 feet).

The designer should request from the WSDOT Materials Laboratory a geotechnical report for the project that evaluates any potential structural site instability due to extended subgrade saturation and/or head loading of the permeable layer, including the potential impacts to downgradient properties (especially on hills with known side-hill seeps). The report should address the adequacy of the proposed detention tank locations and recommend the necessary setbacks from any steep slopes and building foundations.

General Maintenance Requirements

For general maintenance requirements, see Section 5.

2 Media Filtration BMPs

BMP RT.14 Sand Filter Basin

WSDOT does not recognize this BMP as a viable highway application for basic or enhanced treatment due to cost and performance considerations associated with maintaining this treatment option. For instructions on seeking approval for using this BMP, refer to Section 5-3.6, Seeking Authorization for Alternative BMP Options, in Chapter 5 of the Highway Runoff Manual.

Introduction

General Description

Sand filter basins operate much like runoff treatment infiltration ponds (see Figures RT.14.1 through RT.14.4). However, instead of infiltrating to native soils, stormwater filters through a constructed sand bed with an underdrain system. Runoff enters the sand filter bed area and spreads over the surface of the filter. As flows increase, water ponds to a greater depth above the filter bed until it can percolate through the sand. Common configurations for this BMP are open basins with side slopes similar to stormwater ponds and open basins with structural walls or stabilized side slopes. The treatment pathway is vertical (downward through the sand) rather than horizontal as it is in biofiltration swales and filter strips. High flows in excess of the runoff treatment goal simply spill out over the top of the facility. Water that percolates through the sand is collected in an underdrain system of drain rock and perforated pipes, which directs the treated runoff to the downstream drainage system.

A sand filter removes pollutants by filtration. As stormwater passes through the sand, pollutants are trapped in the small spaces between sand grains or adhere to the sand surface. Over time, soil bacteria will also grow in the sand bed, and some biological treatment may occur.

Sand filter basins can be designed in two sizes: basic and large. Based upon experience in King County, Washington, and Austin, Texas, basic sand filters should be capable of achieving the following average pollutant-removal goals:

- 80% TSS removal at influent event mean concentrations (EMCs) of 30 to 300 milligrams per liter (mg/L) (King County 1998; Chang 2000)
- Oil and grease removal to below 10-mg/L daily average and 15 mg/L at any time, with no ongoing or recurring visible sheen in the discharge

Large sand filters are expected to remove at least 50% of the total phosphorus compounds by collecting and treating a minimum of 91% of the mean annual runoff volume.

Applications and Limitations

Basic sand filters can be used to meet basic runoff treatment objectives (see Table 3-1 in Chapter 3 of the HRM), and large sand filters can be used to treat stormwater for additional removal of phosphorus or dissolved metals. Basic sand filters can also be used as part of a two-facility treatment train to treat stormwater for removal of phosphorus or dissolved metals.

Sand filters can be used where site topography and drainage provide adequate hydraulic head to operate the filter. An elevation difference of at least 4 feet between the inlet and outlet of the filter is usually needed to install a sand filter.

Sand filters can be located off-line before or after detention facilities. On-line sand filters should be located only downstream of a detention facility.

Sand filters are designed to prevent water from backing up into the sand layer from underneath, and thus the underdrain system must drain freely. A sand filter is more difficult to install in areas with high water tables where groundwater could potentially flood the underdrain system. Clearance should be sufficient between the seasonal high groundwater level (highest level of groundwater observed) and the bottom of the sand filter to permit adequate drainage (at least 2 feet is recommended). In high water table areas, adequate drainage of the sand filter may require additional engineering analysis and design considerations.

Water standing in the underdrain system also keeps the sand saturated. Under these conditions, oxygen can be depleted, releasing pollutants such as metals and phosphorus that are more mobile under anoxic conditions.

An underground filter (see BMP RT.15, Linear Sand Filter, or BMP RT.16, Sand Filter Vault) should be considered in areas subject to freezing.

Because the surface of the sand filter clogs with sediment and other debris, this BMP should not be used in areas where heavy sediment loads are expected. A sand filter should not be used during construction to control sediments unless the sand bed is replaced periodically during construction and after the site is stabilized.

Although the sand filter basin BMP may have fairly good applications in urbanized settings where space is limited, its initial high construction cost and high maintenance frequency (and associated costs) make it an undesirable choice of treatment. It should be considered only when no other options are feasible. To ensure that sand filters are used only when absolutely necessary, the HQ Hydraulics Office must approve their use.

Presettling and/or Pretreatment

Pretreatment is necessary to reduce velocities to the sand filter and to remove debris, floatables, large particulate matter, and oils.

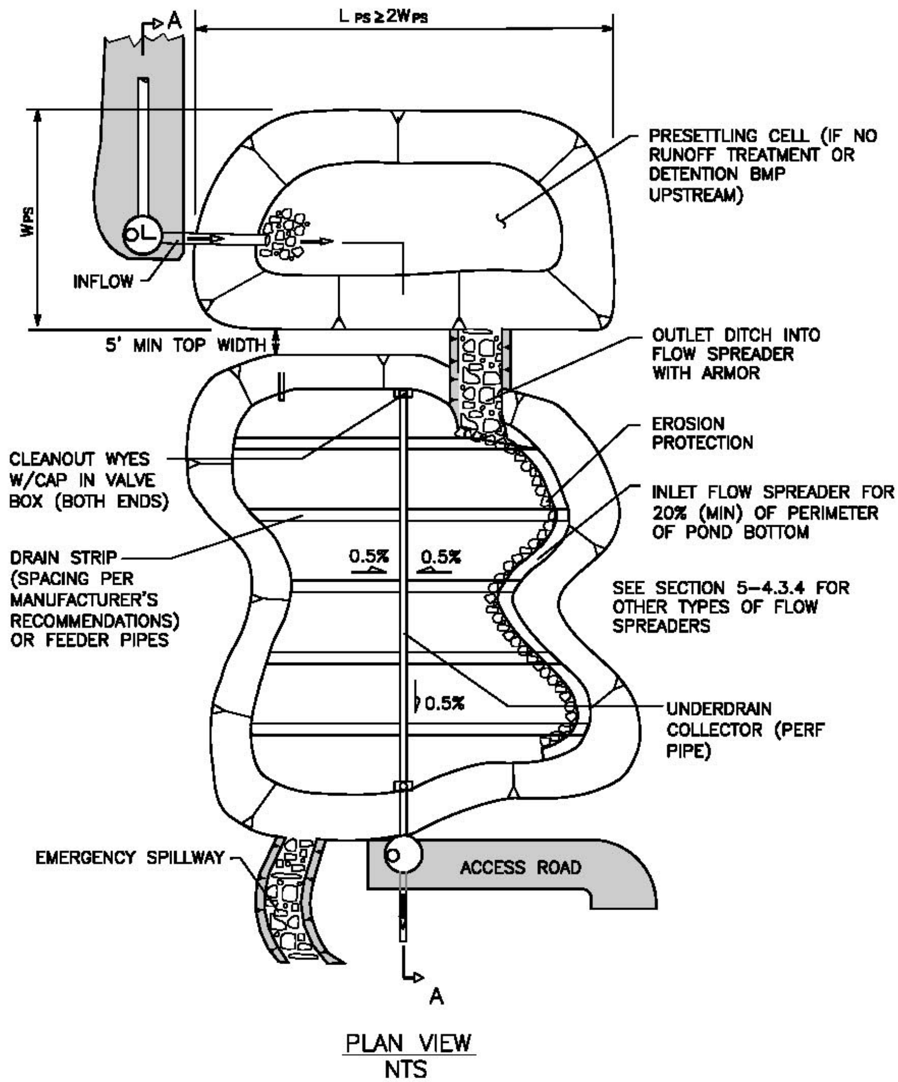


Figure RT.14.1. Sand filter basin with pretreatment cell.

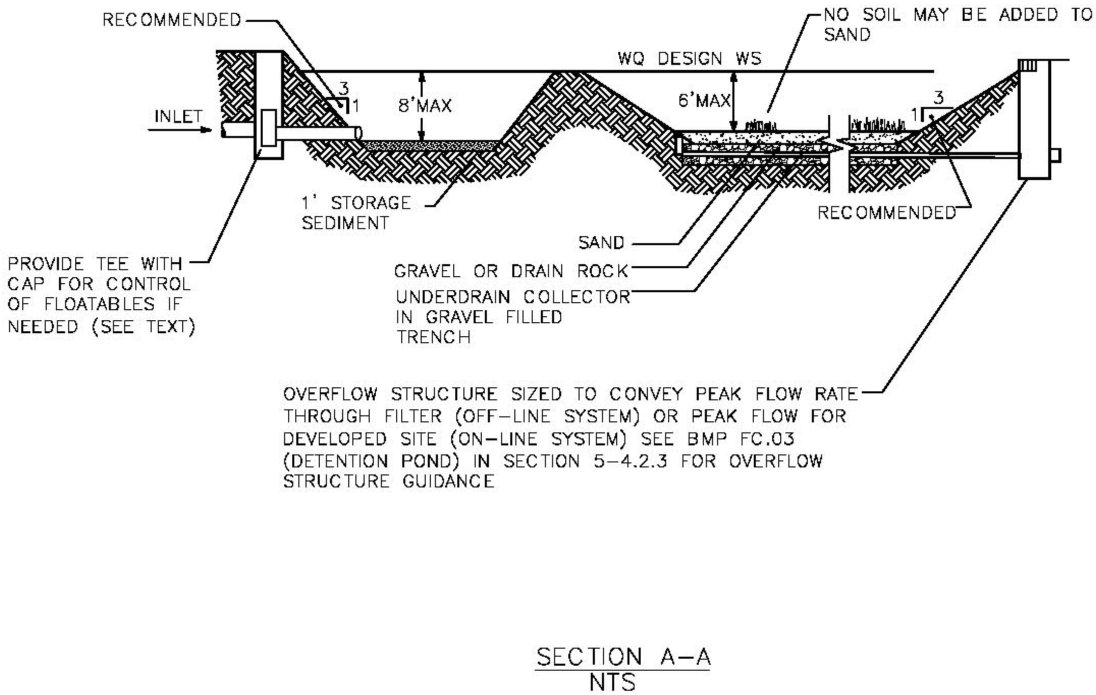


Figure RT.14.2. **Sand filter basin with pretreatment cell: cross section.**

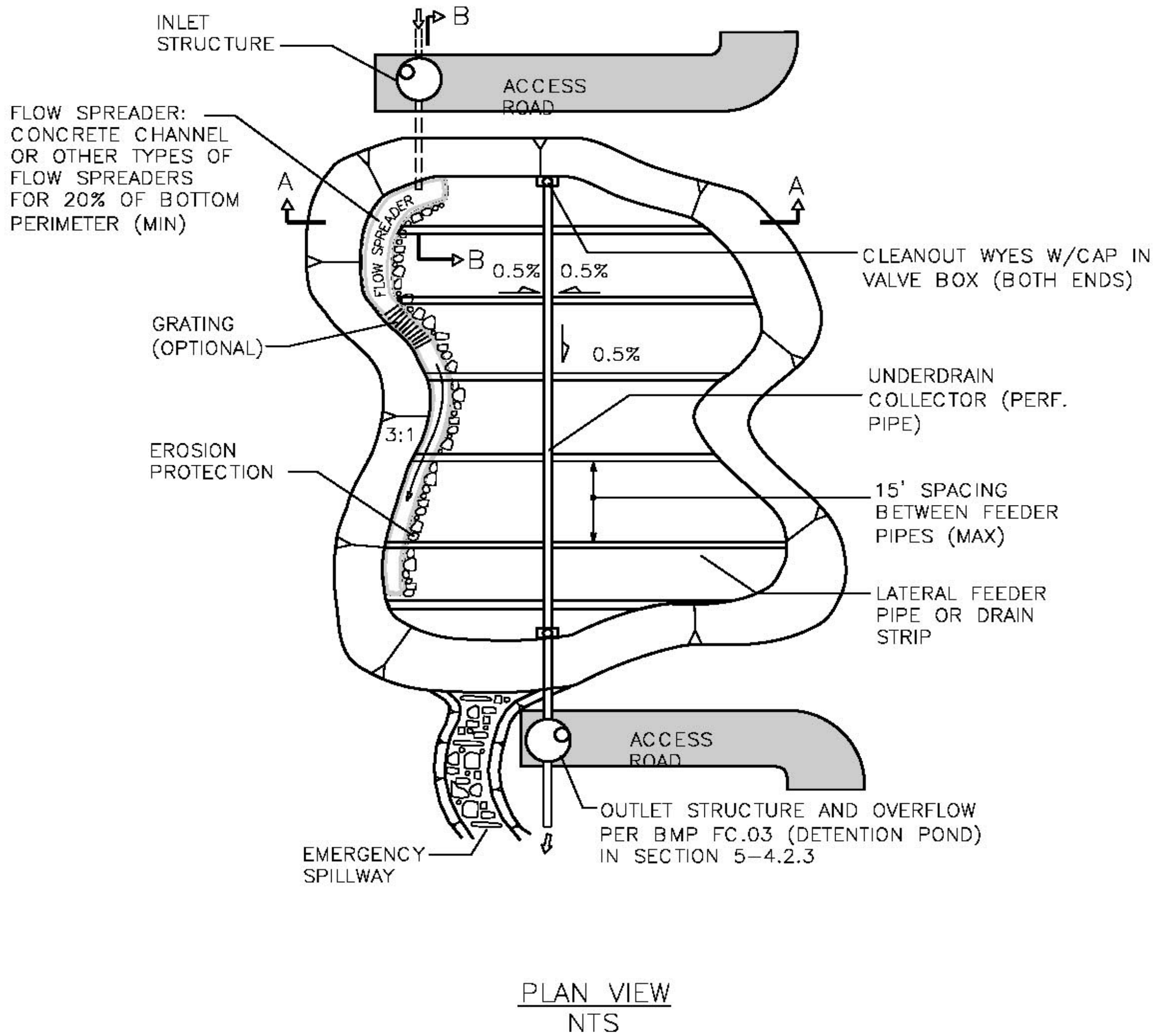


Figure RT.14.3. Sand filter basin with flow spreader.

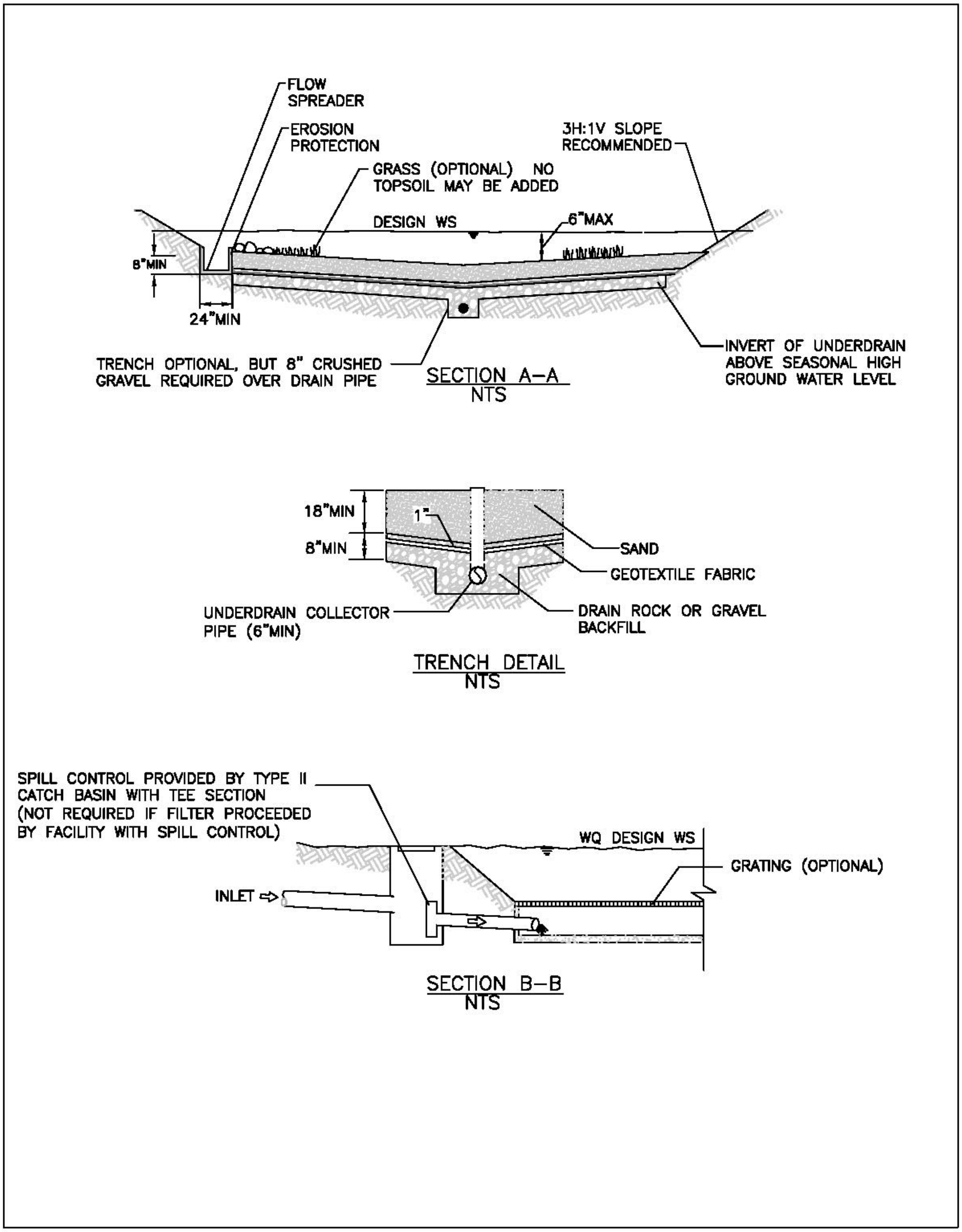


Figure RT.14.4. **Sand filter basin with flow spreader: detail and cross sections.**

Design Flow Elements

Flows to Be Treated

Sand filters are designed to capture and treat the runoff treatment design storm volume when the simple sizing method described below (for eastern Washington) is used. When the continuous runoff model sizing method (for western Washington, also described below) is used, sand filters are designed to capture and treat 91% of the total runoff volume (95% for large sand filters), and bypass or overflow 9% of the total runoff volume (5% for large sand filters).

Overflow or Bypass

Sand filter facilities must include an overflow structure. The overflow elevation should coincide with the maximum design hydraulic head above the sand bed. For overflow structure design guidance, see BMP FC.03 in the HRM.

Location of Sand Filter with Respect to Detention Facilities and Conveyance Systems

The size of the sand filter varies depending on whether it is upstream or downstream of the on-site detention facility. Additionally, the location of the sand filter with respect to the on-site drainage conveyance system dictates the need (or lack thereof) for a flow splitter. Figure RT.14.5 shows various configurations for sand filters in relation to detention facilities and conveyance systems that are referred to throughout this section.

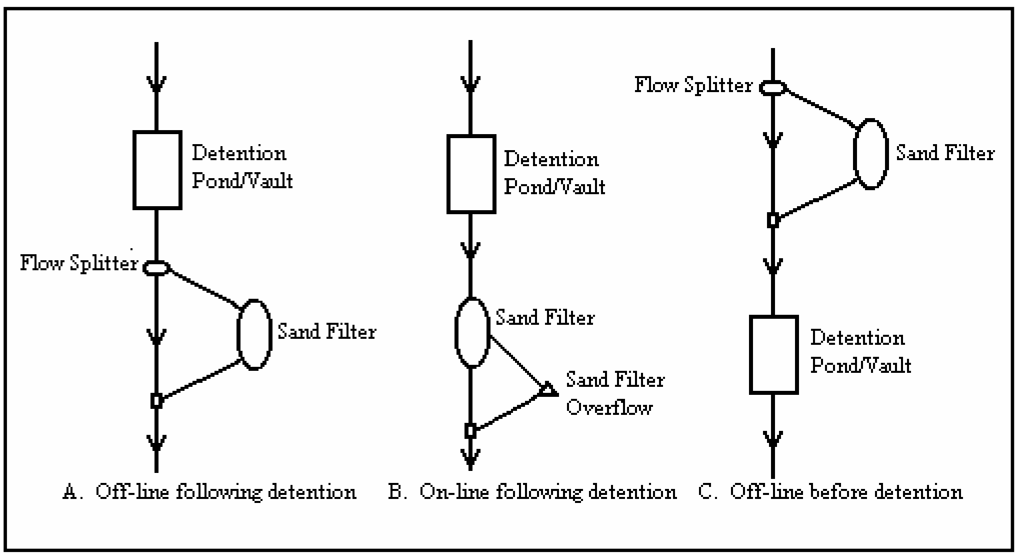


Figure RT.14.5. System layout options for sand filters with detention BMPs.

Flow Splitters

An off-line sand filter must be designed to filtrate all of the water it receives. Therefore, a continuous runoff model that directs all flows at or below a design flow rate to the filter must be used to determine an acceptable combination of filter size and minimum storage reservoir above the filter. The system needs to ensure complete filtration of all runoff directed to the filter. (See Section 5-4.3.4 in Chapter 5 of the HRM for flow splitter design guidance.)

Flow Spreaders

Flow spreading structures (e.g., flow spreaders, weirs, or multiple orifice openings) should be designed to minimize turbulence and to spread the flow uniformly across the surface of the sand filter (see Figures RT.14.3 and RT.14.4). Stone riprap or other energy-dissipation devices should be installed to prevent erosion of the sand medium and to promote uniform flow (see Section 5-4.3.5 in Chapter 5 of the HRM).

Emergency Overflow Spillway

Sand filters designed as on-line facilities must include an emergency overflow spillway. For design guidance, see BMP FC.03 in the HRM.

Structural Design Considerations

A sand filter is designed with two parts: a temporary storage reservoir to store runoff, and a sand filter bed through which the stored runoff percolates. Usually the storage reservoir is placed directly above the filter, and the base of the reservoir is the top of the sand bed. For this case, the storage volume determines the hydraulic head over the filter surface. Greater hydraulic head increases the rate of flow through the sand.

Geometry

Two methods are given here to size sand filters: a simple sizing method (for eastern Washington) and a continuous runoff model sizing method (for western Washington). The simple sizing method uses standard values to define filter hydraulic characteristics for determining the sand surface area. This method is useful for planning purposes, for a first approximation to begin iterations in the detailed method, or when use of the continuous runoff model is not desired or not available.

The continuous runoff model sizing method uses a continuous simulation computer model to determine sand filter area and pond size based on specific site conditions. Use of the continuous runoff model design method very often results in filter sizes that are smaller than those derived by the simple method, especially if the facility is downstream of a detention pond. Both methods include parameters for sizing either a basic or a large sand filter.

For either method, the following design criteria apply:

- Sand filter bed depth: 1.5 to 2.5 feet
- Maximum ponding depth: 1.0 to 6.0 feet
- Percentage of sand filter perimeter with flow spreader: 30% minimum (if the length-to-width ratio of the filter is 2:1 or greater, then a flow spreader must be located on the longer side)

Simple Sizing Method (for Eastern Washington)

This method applies to the off-line placement of a sand filter upstream or downstream of detention facilities. A conservative design approach is described below using a routing adjustment factor. If this approach is used, computations of flow routing through the filter do not need to be performed. An alternative simple approach for off-line placement downstream of detention facilities is to route the full 2-year release peak rate from the detention facility (sized to match the predeveloped peak flow rates) to a sand filter with sufficient surface area and reservoir storage volume to effectively filter the peak flow rate.

Basic Sand Filter

For sizing a basic sand filter, apply a routing adjustment factor of 0.7 to the runoff volume associated with a 6-month, 24-hour storm event to compensate for routing through the sand bed at the maximum ponding depth. Design a flow splitter to route the runoff treatment design flow rate to the sand filter.

Large Sand Filter

For sizing a large sand filter, use the same procedures as for the basic sand filter. Then apply a scale-up factor of 1.6 to the surface area. This is considered a reasonable average for various impervious tributary drainage areas. For a large sand filter upstream or downstream of a detention facility, design a flow splitter to route the runoff treatment flow rate to the sand filter, with the following exceptions:

- For off-line large sand filters, multiply the runoff treatment design flow rate of the basic sand filter by 1.2 to design the flow splitter.
- Apply a scale-up factor of 1.6 to the surface area of the sand filter after sizing the basic sand filter for the 6-month, 24-hour storm according to the design procedure outlined below.

Example Calculation

Design Specifications

The sizing of the sand filter is based on routing the design runoff volume through the sand filter and using Darcy's law to account for variations in flow percolation through the sand bed caused by the hydraulic head variations in the water ponded above the sand bed during and following a storm. Darcy's law is represented by the following equation:

$$Q_{sf} = KiA_{sf} = FA_{sf}$$

where: $i = (h+L)/L$

Therefore, $A_{sf} = Q_{sf}/Ki$

Also, $Q_{sf} = A_t Q_d R/t$

Substituting for Q_{sf}, $A_{sf} = A_t Q_d R/Kit$

Or, $A_{sf} = A_t Q_d R/\{K(h+L)/L\}t$

Or, $A_{sf} = A_t Q_d R/Ft$

where: Q_{sf} = flow rate (ft^3/day) at which runoff is filtered by the sand filter bed

A_{sf} = sand filter surface area (ft^2)

Q_d = design storm runoff depth (ft) for the 6-month, 24-hour storm. Use the SCS curve number equations detailed in Chapter 4 of the HRM to estimate Q_d.

R = routing adjustment factor. Use R = 0.7 (R = 1.0 for large sand filter).

A_t = tributary drainage area (ft^2)

K = hydraulic conductivity of the sand bed (ft/day). Use 2 feet per day for filters with a presettling basin.

i = hydraulic gradient of the pond above the filter (h+L)/L (ft/ft)

F = filtration rate (ft/day) (F = Ki)

d = maximum depth of water over sand filter surface (ft)

h = average depth of water over sand filter surface (ft) (h = d/2)

t = recommended maximum drawdown time (days). In general, 1 day (24 hours) is used from the completion of inflow into the sand filter facility (assume the presettling basin in front of the sand filter is full of water) of a discrete storm event to the completion of outflow from the sand filter underdrain of that same storm event.

L = sand bed depth (ft). Generally use 1.5 feet

Given conditions:

- Sedimentation basin is fully ponded and no ponded water is above the sand filter
- A_t = 10 acres
- Q_d = 0.922 inches (0.0768 ft) for SeaTac rainfall
- Curve number = 96.2 for 85% impervious and 15% till grass tributary surfaces
- R = 0.7
- Maximum drawdown time through sand filter = 24 hours

- Maximum pond depth above sand filter = either 3 feet or 6 feet (two examples are calculated below)
- h = 1.5 feet or 3 feet
- Design hydraulic conductivity of basic sand filter, K = 2.0 feet/day (1 inch/hour).

  Using design equation:

  $$A_{sf} = A_t Q_d RL/Kt(h+L)$$

  At pond depth of 6 feet:

  $$A_{sf} = (10)43{,}560(0.0768)(0.7)(1.5)/(2)(1)(4.5) = 3{,}911 \text{ square feet}$$

  Therefore, A_{sf} for the basic sand filter becomes:

  3,911 square feet at pond depth of 6 feet
  5,867 square feet at pond depth of 3 feet

  Using the 1.6 scale-up factor, the large sand filter design sizes for the conditions of this example become:

  6,258 square feet at pond depth of 6 feet
  9,387 square feet at pond depth of 3 feet

Continuous Runoff Model Sizing Method (for Western Washington)

Basic Sand Filter

This method is intended to capture and treat 91% of the runoff volume (based on a long-term timeseries) through the use of a continuous runoff model coupled with a flow-routing routine that determines stage-storage-discharge relationships. Until a 15-minute timeseries is available, a 1-hour timeseries in a continuous simulation model can be used for facility sizing.

Off-line: An off-line basic sand filter located upstream of detention facilities should have an upstream flow splitter that is designed to bypass the incremental portion of flows above the runoff treatment design flow rate. The long-term runoff timeseries used as input to the sand filter should be modified to use all flows up to the runoff treatment design flow rate and to disregard all flows above that rate. The design overflow volume for off-line sand filters is zero because all flows routed to the filter are at or below the runoff treatment design flow. Therefore, the goal is to size the storage reservoir so that its capacity is not exceeded. (Note: An emergency overflow should nonetheless be included in the design.)

If a modeling routine is not available to modify a runoff timeseries as described above, then the storage reservoir for the off-line facility can be sized as if in an on-line mode. All of the post-development runoff timeseries is routed to the storage reservoir, which is then sized to overflow 9% of the total runoff volume of the timeseries. In actual practice, an off-line flow splitter does not route all of the postdevelopment timeseries to the storage reservoir, and so the reservoir should not overflow if operating within design criteria. This design approach should result in slightly oversizing the storage reservoir.

Downstream of detention facilities, the flow splitter should be designed to bypass the incremental portion of flows above the flow rate that corresponds with treating 91% of the runoff volume of the long-term timeseries. Because flow rates are reduced by the detention facility, this flow rate is lower than the runoff treatment design flow rate for facilities located upstream of detention. Accordingly, the design flow rate should be adjusted to use the flow rate corresponding to treating 91% of the runoff volume from the postdetention runoff timeseries. Note: Downstream of detention facilities, a 1-hour timeseries may be used to compute the sand filter size until such time as a 15-minute timeseries is available. Due to the flow-dampening effect of the detention facilities, there should be little difference between a sand filter sized to treat 91% of the runoff volume using 15-minute versus 1-hour timeseries data.

On-line: Small sand filters that are on-line (i.e., all flows enter the storage reservoir) should be located only downstream of detention facilities to prevent exposure of the sand filter surface to high flow rates that could cause loss of media and previously removed pollutants. The storage pond above the sand bed should be sized to restrict the total amount of overflow from the reservoir to 9% of the total runoff volume of the long-term timeseries.

Large Sand Filter

This method is intended to capture and treat a minimum of 95% of the mean annual runoff volume using a method similar to that described for the basic sand filter basins.

Off-line: An off-line large sand filter should have an upstream flow splitter that is designed to bypass the incremental portion of flows above the flow rate that corresponds with treating 95% of the runoff volume of the long-term timeseries (using 15-minute time steps, if available). The design overflow volume for off-line sand filters is zero because all flows routed to the filter must be treated. Therefore, the goal is to size the storage reservoir so that its capacity is not exceeded. Note: An emergency overflow should nonetheless be included in the design.

Because flow rates are reduced by a detention facility, a large sand filter downstream of detention facilities will be smaller than a filter upstream of detention. A conservative design would use a flow splitter to route the full 2-year release rate from the detention facility, sized to match predeveloped flow durations, to a filter with sufficient surface area to infiltrate at that flow rate. Such a design should treat over 95% of the runoff volume.

On-line: Large sand filters that are on-line (i.e., all flows enter the storage reservoir) should be located only downstream of detention facilities to prevent exposure of the sand filter surface to high flow rates that could cause loss of media and previously removed pollutants. The storage reservoir above the filter bed should be sized to restrict the total amount of overflow from the reservoir to 5% of the total runoff volume of the long-term timeseries. On-line large sand filters are not a preferred design because of the extended timeframe during which the filter is saturated, which reduces the potential for phosphorus removal.

Underdrains

Acceptable types of underdrains include (1) a central collector pipe with lateral feeder pipes, (2) a geotextile drain strip in an 8-inch gravel backfill or drain rock bed, and (3) longitudinal pipes in an 8-inch gravel backfill or drain rock bed with a collector pipe at the outlet end. The following are design criteria for the underdrain piping:

- Where placed upstream of detention facilities, underdrain piping should be sized to convey double the 2-year return frequency flow calculated by a continuous simulation model (the doubling factor is a conversion from the 1-hour time step to a 15-minute time step—omit this factor if a 15-minute time step is available). Downstream of detention, the underdrain piping should be sized for the 2-year return frequency flow calculated by a continuous simulation model.
- Internal diameters of underdrain pipes should be a minimum of 6 inches, with perforations of ½-inch holes spaced 6 inches apart longitudinally (maximum). Rows of perforations should be 120º radially apart (with holes oriented downward). The maximum perpendicular distance between two feeder pipes must be 15 feet. All piping is to be Schedule 40 PVC or greater wall thickness. Drain piping can be installed in basin and trench configurations.
- The main collector underdrain pipe should be at a slope of 0.5% minimum.
- A geotextile fabric for underground drainage (see Section 9-33 of the WSDOT Standard Specifications) must be used between the sand layer and drain rock and placed so that 1 inch of drain rock is above the fabric. Drain rock should be washed free of clay and organic material.

Cleanout wyes with caps or junction boxes must be provided at both ends of the collector pipes. Cleanouts must extend to the surface of the filter. A valve box must provide access to the cleanouts. Access for cleaning all underdrain piping is needed, which may consist of installing cleanout ports that tee into the underdrain system and surface above the top of the sand bed. An inlet shutoff or bypass valve is recommended to facilitate maintenance of the sand filter. Note: Other equivalent energy dissipaters can be used if needed.

Materials

The filter medium in a basic or large sand filter must consist of a sand meeting the size gradation (by weight) given in Table RT.14.1. This gradation is equivalent to fine aggregate Class 1 for Portland Cement Concrete, as referenced in Section 9-03.1(2)B of the Standard Specifications, which can also be used in a sand filter application.

Table RT.14.1. Sand medium specification.

U.S. Sieve Number	Percent Passing
4	95-100
8	70-100
16	40-90
30	25-75
50	2-25
100	<4
200	<2

Berms, Baffles, and Slopes

Side slopes for earthen/grass embankments should not exceed 3H:1V to facilitate mowing.

Liners

- Low-permeability liners should generally be installed below the sand bed for retention of soluble pollutants such as metals and toxic organics and where the underflow could cause problems with nearby structures (see Section 5-4.3.3 in Chapter 5 of the HRM). Low-permeability liners may be made of clay, concrete, or geomembrane materials.
- If a low-permeability liner is not required, then a geotextile fabric liner should be installed that retains the sand and meets underground drainage geotextile specifications listed in Section 9-33 of the WSDOT Standard Specifications, unless the basin has been excavated to bedrock.
- If a low-permeability liner is not provided, then an analysis should be made of the possible adverse effects of seepage zones on groundwater and on nearby building foundations, basements, roads, parking lots, and sloping sites. Sand filters should be located at least 20 feet downslope and 100 feet upslope from building foundations. Sand filters without low-permeability liners should not be built on fill sites.

Site Design Elements

Setback Requirements

Setback requirements for sand filter basins are the same as those for detention ponds (see BMP FC.03 in the HRM).

Landscaping (Planting Considerations)

Landscape uses may be somewhat constrained because the vegetation capable of surviving in sand is limited. Grass has been grown successfully on top of several sand filters in western Washington where the grass seed was tailored for growth in sand with highly variable degrees of saturation. Trees and shrubs that generate a large leaf fall should be avoided in the immediate vicinity of the filter because leaves and other debris can clog the surface of the filter.

Maintenance Access Roads (Access Requirements)

An access ramp, or equivalent access, is necessary for maintenance purposes at the inlet and the outlet of an aboveground sand filter. The ramp slope must not exceed 15%.

BMP RT.15 Linear Sand Filter

WSDOT does not recognize this BMP as a viable highway application for basic or enhanced treatment due to cost and performance considerations associated with maintaining this treatment option. For instructions on seeking approval for using this BMP, refer to Section 5-3.6, Seeking Authorization for Alternative BMP Options, in Chapter 5 of the Highway Runoff Manual.

Introduction

General Description

Linear sand filters are long, shallow, rectangular vaults (see Figure RT.15.1) housing the same type and depth of sand media specified in BMP RT.14, Sand Filter Basin. They typically consist of two cells or chambers, one for settling the coarse sediment in the runoff entering the filter facility and the other for housing the sand filter media. Stormwater flows from the settling cell into the sand filter cell via a weir section that also functions as a flow spreader to distribute the flow over the sand. The outlet consists of an underdrain pipe system that connects to the storm drain system.

Applications and Limitations

Linear sand filters can be designed in two sizes: basic and large. Basic linear sand filters can be used to meet oil control and basic runoff treatment requirements (see Table 3-1 in Chapter 3 of the HRM) or as part of a two-facility treatment train for phosphorus or enhanced treatment. Large linear sand filters are used to meet the enhanced treatment objectives.

Linear sand filters are designed to treat runoff from high-use sites (see Section 5-3.5, Step 3, in Chapter 5 of the HRM) for removal of TSS and oil and grease. They are best suited for treating runoff from small drainage areas (less than 5 acres), particularly long, narrow spaces such as the perimeter of a paved surface. The goal is to keep linear sand filters fairly shallow and narrow. A linear sand filter can be located along the perimeter of a paved impervious surface and can be installed upstream or downstream of a vegetated filter strip. If used for oil control, the filter should be located upstream from the main runoff treatment facility (i.e., wet pond, biofiltration swale, bioinfiltration swale, or combined detention and wet pond).

Presettling and/or Pretreatment

A sediment chamber is included in linear sand filter design. If the sand filter is preceded by another runoff treatment facility and the flow enters the sand filter as sheet flow, the requirement for the sediment cell may be waived.

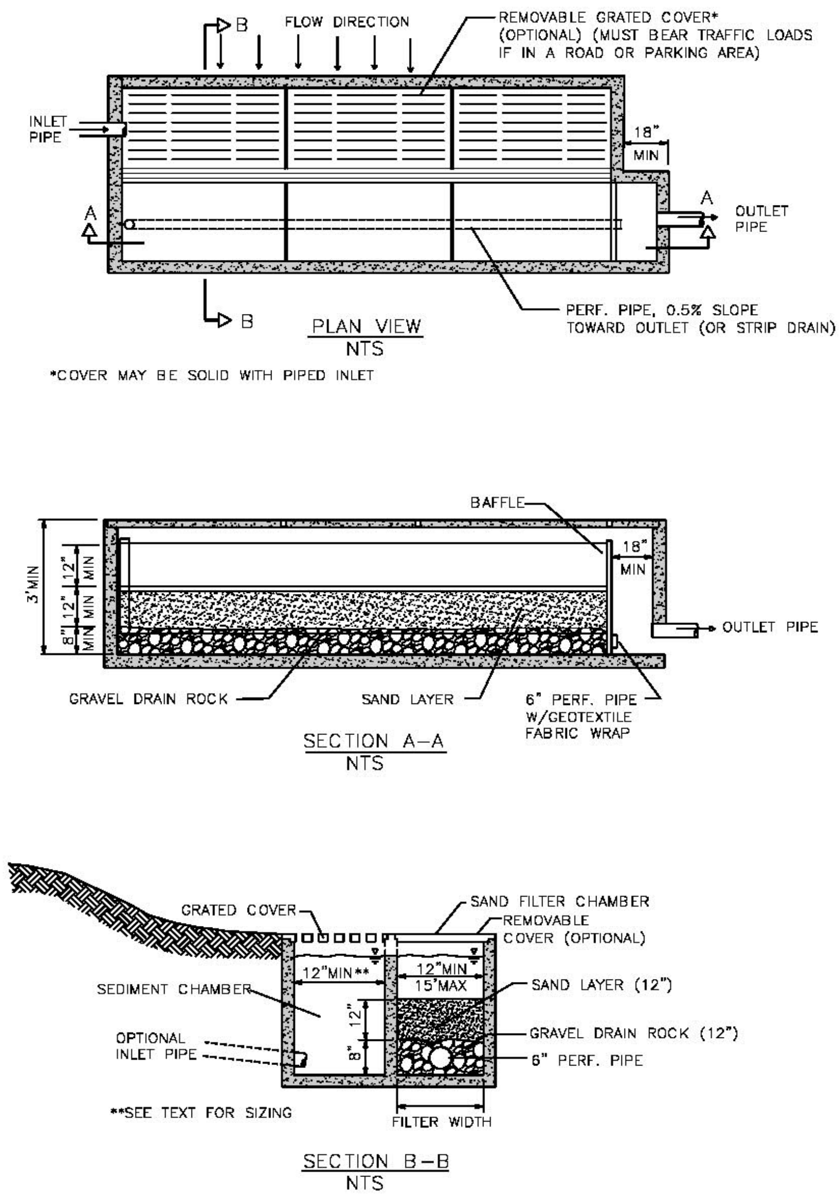


Figure RT.15.1. Linear sand filter with sediment chamber.

Design Flow Elements

Flows to Be Treated

The flows to be treated by linear sand filters are the same as those for sand filter basins (see BMP RT.14).

Flow Spreaders

The weir section dividing the presettling and sand filter cells functions as a flow spreader.

Emergency Overflow Spillway

A linear sand filter must have a surface overflow spillway, a piped overflow, or other emergency overflow route for safely controlling the overflow. The overflow must meet the conveyance requirements specified in the WSDOT *Hydraulics Manual*.

Structural Design Considerations

Geometry

Calculate sand filter area using one of the methods described in BMP RT.14. The width of the sand cell must be 1 foot minimum, up to 15 feet maximum. The sand filter bed must be a minimum of 12 inches deep and have an 8-inch layer of drain rock with perforated drainpipe beneath the sand layer.

Set sedimentation cell width as follows:

Sand filter width (w), inches	12-24	24-48	48-72	72+
Sedimentation cell width, inches	12	18	24	w/3

Stormwater may enter the sedimentation cell as sheet flow or via a piped inlet. The two cells should be separated by a divider wall that is level and extends a minimum of 12 inches above the sand bed.

The drainpipe must be a minimum 6-inch diameter, wrapped in geotextile fabric, and sloped a minimum of 0.5%.

If separated from traffic areas, a linear sand filter may be covered or open. If covered, the cover must be removable for the entire length of the filter. Covers must be grated if flow to the filter is from sheet flow. Covered linear sand filters must be vented as described for sand filter vaults (see BMP RT.16).

Materials

Linear sand filters must conform to the materials and structural suitability criteria specified for detention vaults (see BMP FC.04).

Specifications for sand media and drain rock are the same as those for sand filter basins (see BMP RT.14).

Site Design Elements

Setback Requirements

Setback requirements for linear sand filters are the same as those for detention vaults (see BMP FC.04).

Maintenance Access Roads (Access Requirements)

Maintenance access provisions are the same as those required for detention vaults (see BMP FC.04), except that if the linear sand filter is covered, the cover must be removable for the entire length of the filter.

BMP RT.16 Sand Filter Vault

> *WSDOT does not recognize this BMP as a viable highway application for basic or enhanced treatment due to cost and performance considerations associated with maintaining this treatment option. For instructions on seeking approval for using this BMP, refer to Section 5-3.6, Seeking Authorization for Alternative BMP Options, in Chapter 5 of the Highway Runoff Manual.*

Introduction

General Description

Sand filter vaults are similar to sand filter basins, except that the sand layer and underdrains are installed below grade in a vault (see Figures RT.16.1 and RT.16.2). Like an aboveground sand filter, a sand filter vault can be sized as either a basic or a large facility to meet different runoff treatment objectives. The basic sand filter vault is designed to meet a performance goal of 80% TSS removal for the runoff treatment design flow. In addition, the large sand filter vault is expected to meet a performance goal of 50% total phosphorus removal.

Applications and Limitations

Basic sand filter vaults can be used to meet basic runoff treatment objectives (see Table 3-1 in Chapter 3 the HRM), and large sand filter vaults can be used to treat stormwater for additional removal of phosphorus or dissolved metals. Basic sand filter vaults can also be used as part of a two-facility treatment train to treat stormwater for removal of phosphorus or dissolved metals.

A sand filter vault can be used on sites where space limitations preclude the installation of aboveground facilities. In highly urbanized areas, particularly on redevelopment and infill projects, a vault is a viable alternative to other treatment technologies that require more area to construct.

Like aboveground sand filter basins (see BMP RT.14), sand filter vaults are not suitable for areas with high water tables where infiltration of groundwater into the vault and underdrain system interferes with the hydraulic operation of the filter. Soil conditions in the vicinity of the vault installation should be evaluated to identify special design or construction requirements for the vault.

It is desirable to have an elevation difference of 4 feet between the inlet and outlet of the filter for efficient operation. Therefore, site topography and drainage system hydraulics must be evaluated to determine whether use of an underground filter is feasible.

Because the surface of a sand filter bed is prone to clogging from sediment and other debris, this BMP should not be used in areas where heavy sediment loads are expected.

Sand filter vaults should be located off-line before or after detention facilities. However, if necessary, vaults may be located on-line for small drainages or a detention facility. Overflow or bypass structures must be carefully designed to handle the larger storms.

Although this BMP may have fairly good applications in urban settings where space is limited, its initial high construction cost and high maintenance frequency (and associated costs) make it an undesirable choice of treatment. It should be considered only when no other options are feasible. To ensure that sand filter vaults are only used when absolutely necessary, the HQ Hydraulics Office must approve their use**.**

Presettling and/or Pretreatment

Pretreatment is necessary to reduce flow velocities entering the sand filter and to remove debris, floatables, large particulate matter, and oils. A pretreatment cell is included as a part of sand filter vault design.

Design Flow Elements

Flows to Be Treated

The flows to be treated by sand filter vaults are the same as those for sand filter basins (see BMP RT.14).

Overflow or Bypass

Sand filters designed as on-line facilities must include an overflow structure for flows greater than the design flow (see Figure RT.16.2).

Flow Splitters

In an off-line system, a diversion structure should be installed to divert the design flow rate into the sediment chamber and to bypass higher flows. (See Section 5-4.3.4 in Chapter 5 of the HRM for flow bypass design guidance.)

Flow Spreaders

A flow spreader must be installed at the inlet to the filter bed to evenly distribute incoming runoff across the filter and prevent erosion of the filter surface.

The flow spreader must be positioned so that the top of the spreader is no more than 8 inches above the top of the sand bed, and at least 2 inches higher than the top of the inlet pipe if a pipe and manifold distribution system is used. (See Section 5-4.3.5 in Chapter 5 of the HRM for flow spreader design options.) For vaults with presettling cells, a concrete sump-type flow spreader must be built into or affixed to the divider wall. The sump must be a minimum of 1 foot wide and extend the width of the sand filter. The downstream lip of the sump must be no more than 8 inches above the top of the sand bed (see Figure RT.16.2).

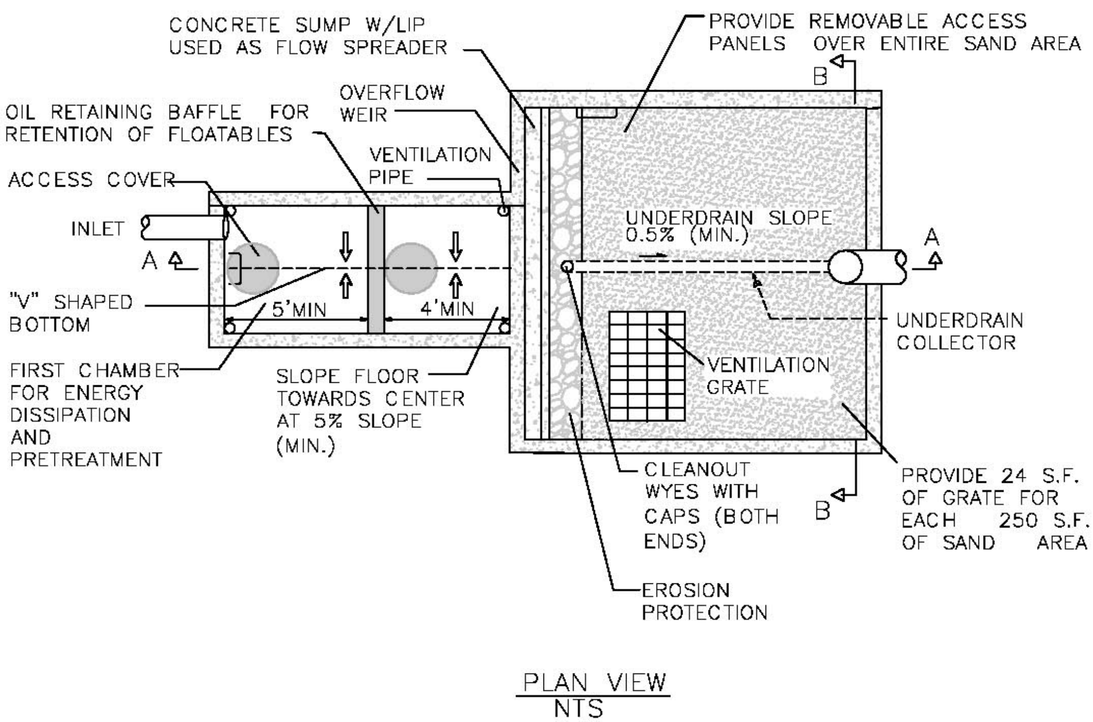


Figure RT.16.1. **Sand filter vault.**

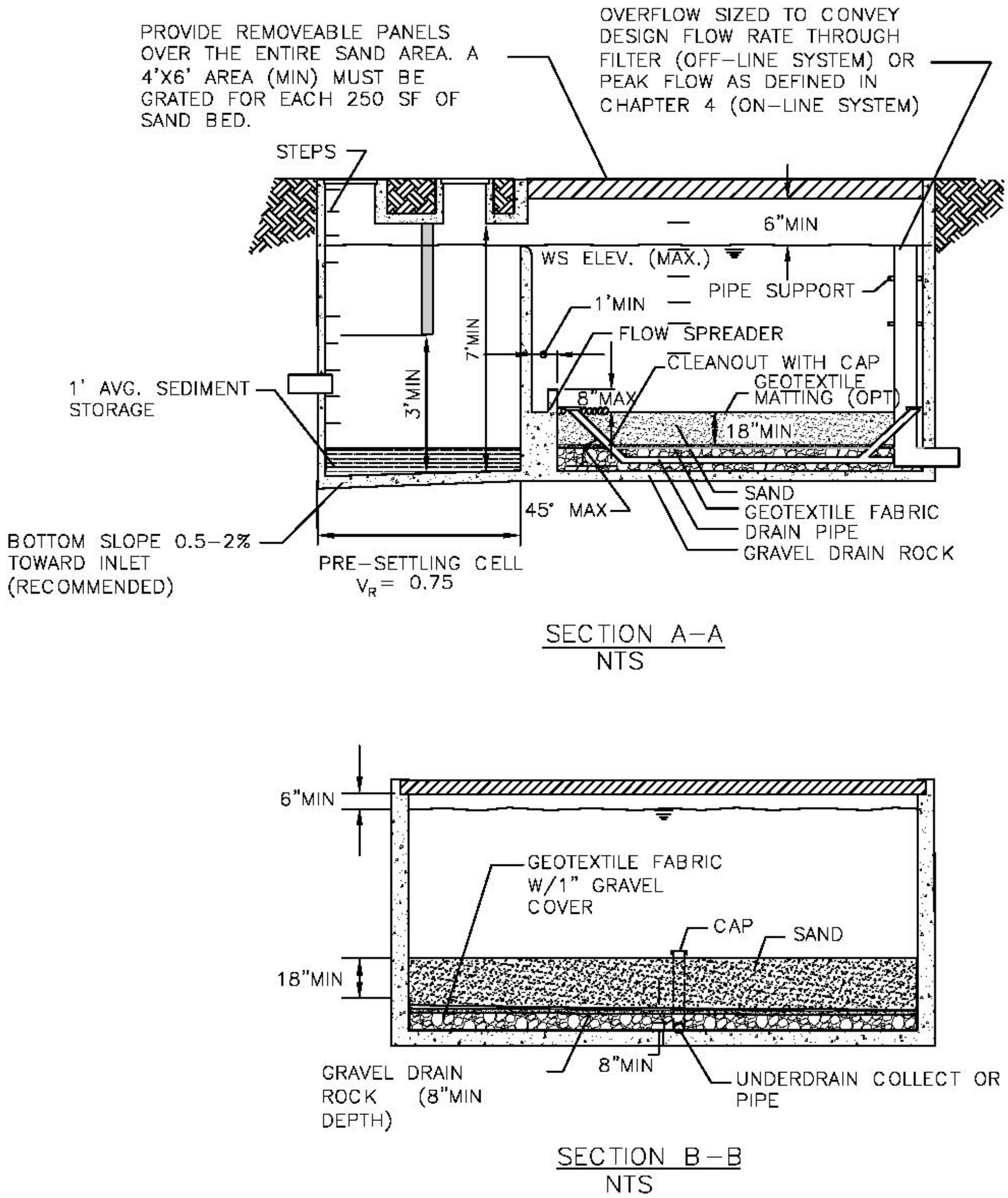


Figure RT.16.2. Sand filter vault: cross sections.

Flows may enter the sand bed by spilling over the top of the wall into a flow spreader pad. Alternatively, a pipe and manifold system may be designed to deliver water through the wall to the flow spreader. If an inlet pipe and manifold system are used, the minimum pipe size should be 8 inches. Multiple inlets are recommended to minimize turbulence and reduce local flow velocities.

Note: Water in the first or presettling cell is dead storage. Any pipe and manifold system design must retain the required dead storage volume in the first cell, minimize turbulence, and be readily maintainable.

Erosion protection must be provided along the first foot of the sand bed width adjacent to the spreader. Geotextile fabric secured on the surface of the sand bed, or an equivalent method, may be used.

Structural Design Considerations

Geometry

The sand filter area is calculated using one of the methods described in BMP RT.14.

The presettling cell must be designed as described in BMP RT.24 in the HRM. The bottom may be longitudinally level or inclined toward the inlet. To facilitate sediment removal, the bottom must also slope from each side toward the center at a minimum of 5%, forming a broad V. Note that more than one V may be used to minimize cell depth.

Exception: The bottom of the presettling cell may be flat rather than V-shaped if removable panels are installed over the entire presettling cell.

An average 1 foot of sediment storage must be provided in the presettling cell.

To prevent anoxic conditions, a minimum of 24 square feet of ventilation grate should be provided for each 250 square feet of sand bed surface area. For sufficient distribution of airflow across the sand bed, grates may be located in one area if the sand filter is small, but placement at each end is preferred. Small grates may also be dispersed over the entire sand bed area.

Note: If a vault is over 20 feet in width, then it must be designed by the HQ Bridge and Structures Office, and added to the bridge inspection inventory by the Preservation Section.

Intent: Grates are important to allow air exchange above the sand. Poor air exchange hastens anoxic conditions, which may result in release of pollutants such as phosphorus and metals, and may cause objectionable odors.

Materials

Sand filter vaults must conform to the materials and structural suitability criteria specified for detention vaults (see BMP FC.04).

Vaults must have removable panels over the entire area of the sand filter bed. The panels must be at grade, have stainless steel lifting eyes, and weigh no more than five tons per panel. If located within the roadway, the panels must meet H-20 wheel loading requirements.

The filter bed should consist of a top layer of sand, an underlying layer of sand encased in geotextile fabric, and an underdrain system at the bottom. The geotextile fabric protects the intermediate layer from clogging so that periodic filter reconditioning can focus on the top layer of the bed. The specifications for each of these layers are the same as those for sand filter basins (see BMP RT.14).

A geotextile fabric may be installed over the entire sand bed to trap trash and litter. It must be flexible, highly permeable, a three-dimensional matrix, and adequately secured.

Berms, Baffles, and Slopes

If an oil-retaining baffle is used for control of floatables in the presettling cell, it must:

- Extend from 1 foot above to 1 foot below the runoff treatment design water surface (minimum requirements).
- Be spaced a minimum of 5 feet horizontally from the inlet.
- Provide for passage of flows in the event of plugging.

Site Design Elements

Setback Requirements

Setback requirements for sand filter vaults are the same as those for detention vaults (see BMP FC.04).

Maintenance Access Roads (Access Requirements)

Maintenance access requirements for sand filter vaults are the same as those for detention vaults (see BMP FC.04), except for the following modifications:

- Provide maintenance vehicle access to enable removal of all panels atop the sand filter bed and presettling cell (if applicable)
- Provide an access opening and ladder on both sides of the oil-retaining baffle into the presettling cell
- Install an inlet shutoff/bypass valve for maintenance

BMP RT.18 StormFilter™

WSDOT does not recognize this BMP as a viable highway application for basic treatment or for enhanced treatment when used as part of a treatment train due to cost and performance considerations associated with maintaining this treatment option. For instructions on seeking approval for using this BMP, refer to Section 5-3.6, Seeking Authorization for Alternative BMP Options, in Chapter 5 of the Highway Runoff Manual.

Introduction

General Description

StormFilter™ is a proprietary media filtration system developed by Stormwater Management, Inc. (http://www.stormwatermgt.com/). StormFilter™ systems use rechargeable cartridges filled with filtration media to provide runoff treatment that can be used to fulfill Minimum Requirement 5 (in Chapter 3 of the HRM) for basic stormwater treatment.

The filter cartridges are housed in vaults that range in size from single-cartridge catch basin units, to precast linear vaults (see Figure RT.18.1) and standard-sized precast vaults, to larger cast-in-place vaults. The vaults can be open-topped or covered with load-bearing lids. The cartridges contain a basket that is filled with one or more media types, allowing the StormFilter™ to be customized for each site to target specific levels of pollutants, including sediments, floatables, oil and grease, dissolved metals, dissolved phosphorus, and organics (see Table RT.18.1). Common media are compost, perlite, and zeolite. Other media include modified zeolite infused with iron to capture dissolved phosphates and nitrates, and activated carbon to capture organics.

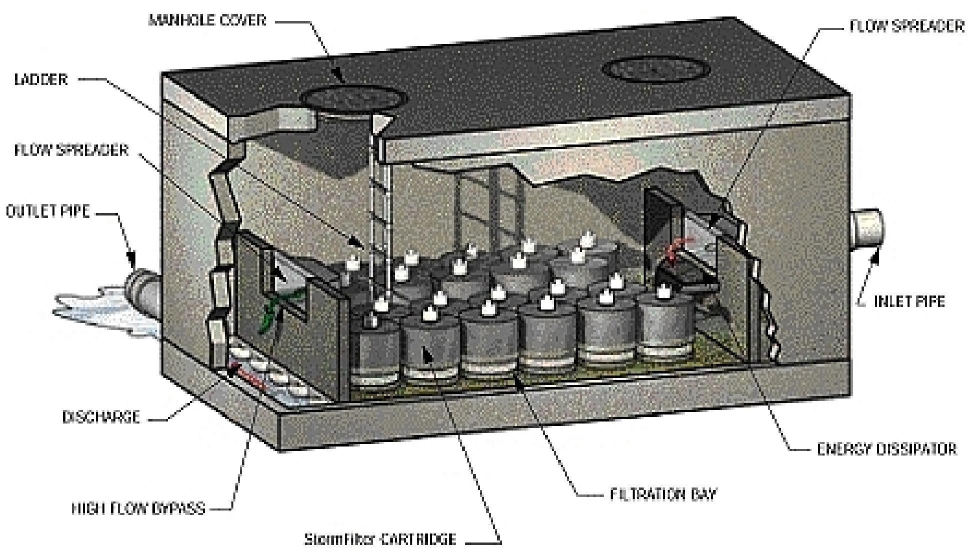


Figure RT.18.1. Precast StormFilter™.
(Courtesy Stormwater Management, Inc.)

Table RT.18.1. Media selection guide.

Pollutant	Medium and Ability to Treat Pollutant			
	Compost	**Perlite**	**Zeolite**	**Modified Zeolite**
TSS	Good	Excellent		
Oil and grease	Excellent	Excellent		
Dissolved metals	Excellent		Excellent	Good
Total phosphorus	Good	Good		
Total nitrogen	Good	Good		
Phosphate	Elevates			Good
Nitrate	Elevates			Good

The proprietary cartridge design uses vacuum to draw stormwater into the cartridge hood in a way that optimizes the vertical surface area of the filtration media (see Figure RT.18.2). The cartridge design also reduces the tendency for the system to plug with fines and sediment, which is characteristic of many sand filters or other horizontal bed systems.

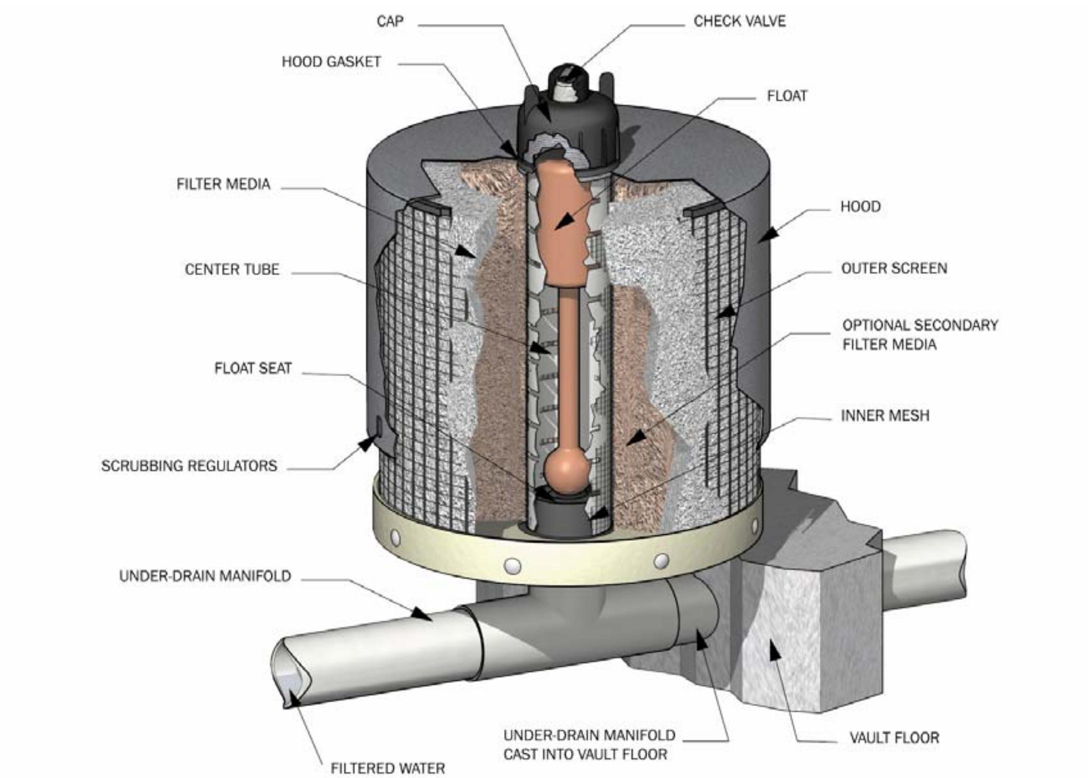


Figure RT.18.2. StormFilter™ cartridge.
(Courtesy Stormwater Management, Inc.)

Applications and Limitations

StormFilter™ systems are versatile and can be used in a variety of applications. They can be used on-line or off-line, as a stand-alone stormwater treatment system, or as part of a treatment train. Most are designed with sedimentation bays for primary removal of coarse sediment, oils, grease, and floatables, thus treating all the runoff in a stand-alone unit. They can also be used as the enhanced treatment component of a treatment train designed to target specific dissolved pollutants. Applications include:

- Urban areas or parking lots where space is limited (the systems can be contained in underground vaults with load-bearing lids).
- Enhanced treatment systems for dissolved metals, using compost media, zeolite, or modified zeolite media inside the cartridge baskets.
- Bridge decks, where StormFilter™ catch basin units can be used (see Figures RT.18.3 and RT.18.4). These catch basins are designed with a standard grate and an access lid for inspection and maintenance of the filter cartridges. They have a sedimentation bay, an oil/water separation baffle, and one or two cartridges. They also have a high-flow bypass to prevent the catch basin from flooding the roadway in the event of an intense storm or filter failure.

Figure RT.18.3. StormFilter™ catch basin in a bridge deck.
(Courtesy Stormwater Management, Inc.)

Figure RT.18.4. StormFilter™ catch basin in a bridge deck from under the bridge.
(Courtesy Stormwater Management, Inc.)

Limitations are the initial construction and annual maintenance costs. Another limitation is that a vertical drop of 2.3 to 3.5 feet is necessary, which limits the use of this BMP in some areas.

At this time, the StormFilter™ BMP has general use approval by the Washington State Department of Ecology (Ecology) for basic runoff treatment of TSS and for use as a secondary treatment facility within a treatment train for dissolved metals. Conditions of the general use designation include:

- StormFilter™ systems containing compost media or perlite are approved for basic treatment at 7.5 gallons per minute (gpm) to target TSS. Compost media can release low amounts of soluble nutrients and should not be applied in nutrient-sensitive discharge areas.

- StormFilter™ systems must be installed in such a manner that flows exceeding 7.5 gpm per cartridge are bypassed around the system or do not resuspend treated sediments.
- StormFilter™ systems should be designed with a minimum of 2.3 feet of head differential between the invert of the inlet and the invert of the outlet.
- Pretreatment to remove excessive solids, hydrocarbons, or debris should be addressed during the design phase.

For more information on the conditional use designation, see the Ecology web site:
http://www.ecy.wa.gov/programs/wq/stormwater/newtech/media_filtration.html

Because this BMP is still considered experimental for enhanced treatment, approval from the region and HQ Hydraulics offices and the region Water Quality Office, as well as a monitoring plan, are required when this BMP is proposed in a treatment train for enhanced treatment.

Pretreatment may be desirable depending on the application. Two methods are used to size the systems. The first is a mass loading calculation that assumes each cartridge can handle 15 pounds of sediment before becoming 50% plugged. The second sizing method estimates the contact time required for the media to remove dissolved pollutants. If pretreatment is used to remove sediment upstream of the StormFilter™, then the mass loading method does not control the design, thereby reducing the system size to only the number of cartridges necessary for enhanced treatment.

Adding a live storage component to a pretreatment cell can also be used to reduce the flow rate to the StormFilter™ system, further reducing the number of cartridges needed. For example, in a situation where the peak flow rate entering a treatment train during the runoff treatment design storm had a flow rate of 4.0 cubic feet per second (cfs), live storage was added to the pretreatment cell to reduce the flow rate to the StormFilter™ to 0.40 cfs. The number of cartridges needed was thus reduced by a factor of 10.

Design Flow Elements

StormFilter™ systems are versatile and can be designed in a variety of applications, including on-line to handle all the flow from a site, off-line to handle only the runoff treatment flows, and as a component in a treatment train to target a specific pollutant. Flow rates range from 5 to 15 gpm (although Ecology has set the maximum flow rate at 7.5 gpm). Stormwater Management, Inc. has developed a design manual and offers technical support for design, sizing, and cost estimating.

Structural Design Considerations

For bridge deck applications, catch basin units can be manufactured from steel using powder-coated epoxy; for marine applications, concrete can be used.

Site Design Elements

Setback Requirements

Setback requirements for StormFilter™ vaults are the same as those for detention vaults (see BMP FC.04).

Maintenance Access Roads (Access Requirements)

Maintenance access requirements for StormFilter™ vaults are the same as those for detention vaults (see BMP FC.04), except for the following modifications:

- Maintenance vehicle access must be provided to enable removal of filter cartridges via the manholes atop the structure
- An inlet shutoff/bypass valve must be installed for maintenance

Maintenance

Maintenance typically includes removing and replacing old cartridges with new and removing accumulated sediment by Vactor truck. The maintenance cycle is typically once per year. Either WSDOT can maintain the system, or it can set up a maintenance agreement with Stormwater Management, Inc. to change the filters, clean the vaults, and dispose of the waste.

3 Oil Control BMPs

BMP RT.20 Baffle-Type (API) Oil/Water Separator

WSDOT does not recognize this BMP as a viable highway application for oil control due to cost and performance considerations associated with maintaining this treatment option. For instructions on seeking approval for using this BMP Refer to Section 5-3.6, Seeking Authorization for Alternative BMP Options, in Chapter 5 of the Highway Runoff Manual.

Introduction

General Description

Baffle-type (API) oil/water separators are multicelled vaults separated by baffles extending down from the top of the vault (see Figure RT.20.1). The baffles impede oil flow out of the vault by inducing oil to float to the water surface in the baffled compartments. Additional baffles are also commonly installed at the bottom of the vault to trap solids and sludge that accumulate over time. A spill control separator (see Figure RT.20.2) is a simple catch basin with a tee inlet for temporarily trapping small volumes of oil. The spill control separator included below is for comparison only and is not intended to be used for treatment purposes. In many situations, simple floating skimmers or more sophisticated mechanical skimmers are installed to remove the oil once it has separated from the water.

Oil/water separators are meant to treat stormwater runoff from areas with intensive land use, such as high-use sites, and from facilities that produce relatively high concentrations of oil and grease. Although baffle-type separators historically have been used to remove larger oil droplets (150 microns or larger), they can also be sized to remove smaller oil droplets. Baffle-type separators can be used to meet a performance goal of 10 to 15 milligrams per liter oil concentration by designing the unit to remove oil droplets 60 microns and larger.

Applications and Limitations

Baffle-type oil/water separators can be used to meet oil control requirements when a site meets the criteria described in Section 5-3.5, Step 3, in Chapter 5 of the HRM. Separators should be used where free oil is expected to be present at treatable high concentrations and sediment will not overwhelm the separator. For low concentrations of oil, other treatment methods (such as sand filters or emerging technologies) may be more applicable.

For inflows from small drainage areas (fueling stations, maintenance shops, etc.), a coalescing plate separator (see BMP RT.21) is typically considered due to space limitations. However, if the plates are likely to become plugged, then a new design basis for the baffle-type separator may be considered on an experimental basis. (See the *Structural Design Considerations* below.)

Oil/water separators are designed to remove free oil and are not generally effective in separating oil that has become either chemically or mechanically emulsified and dissolved in water. Therefore, it is desirable that separators be installed upstream of drainage facilities and conveyance structures that introduce flow turbulence and consequently promote emulsification. Emulsification of oil can also result wherever surfactants or detergents are used to wash vehicles and in parking/maintenance areas that drain to the separator. Detergents should not be used to clean vehicles or in parking/ maintenance areas unless the wash water is collected and disposed of properly (usually to the sanitary sewer).

Without intense maintenance, oil/water separators may not be sufficiently effective in removing oil and total petroleum hydrocarbons (TPH) down to desired levels. Excluding runoff from unpaved areas helps to minimize the amount of sediment entering the vault, reducing the need for maintenance. A unit that fails and ceases to function can release previously trapped oil to the downstream receiving water, both from the oily sediments and the entrainment of surface oils.

In moderately pervious soils where seasonal groundwater may induce flotation, buoyancy of the separator vault structure must be balanced by ballasting or other methods, as appropriate.

Wet vaults may also be modified to function as baffle-type oil/water separators (see design criteria for wet vaults, BMP RT.19).

Construction of oil/water separators should follow and conform to the manufacturer's recommended construction procedures and installation instructions as well as the WSDOT Standard Specifications. After the oil/water separator is installed, it must be thoroughly cleaned and flushed before it begins operating.

Presettling and/or Pretreatment

Pretreatment should be considered if the level of TSS in the inlet flow would impair the long-term efficiency of the separator.

Design Flow Elements

Flows to Be Treated

Oil/water separators must be designed to treat 2.15 times the runoff treatment design flow rate (see Section 3-3.5, Minimum Requirement 5, in Chapter 3 of the HRM). Hydrologic methods are presented in Sections 4-3 and 4-4 in Chapter 4 of the HRM.

Flow Splitters

Oil/water separators must be installed off-line from the primary drainage system. All flows greater than 2.15 times the runoff treatment design flow must bypass the separator. For flow splitter design guidelines, see Section 5-4.3.4 in Chapter 5 of the HRM.

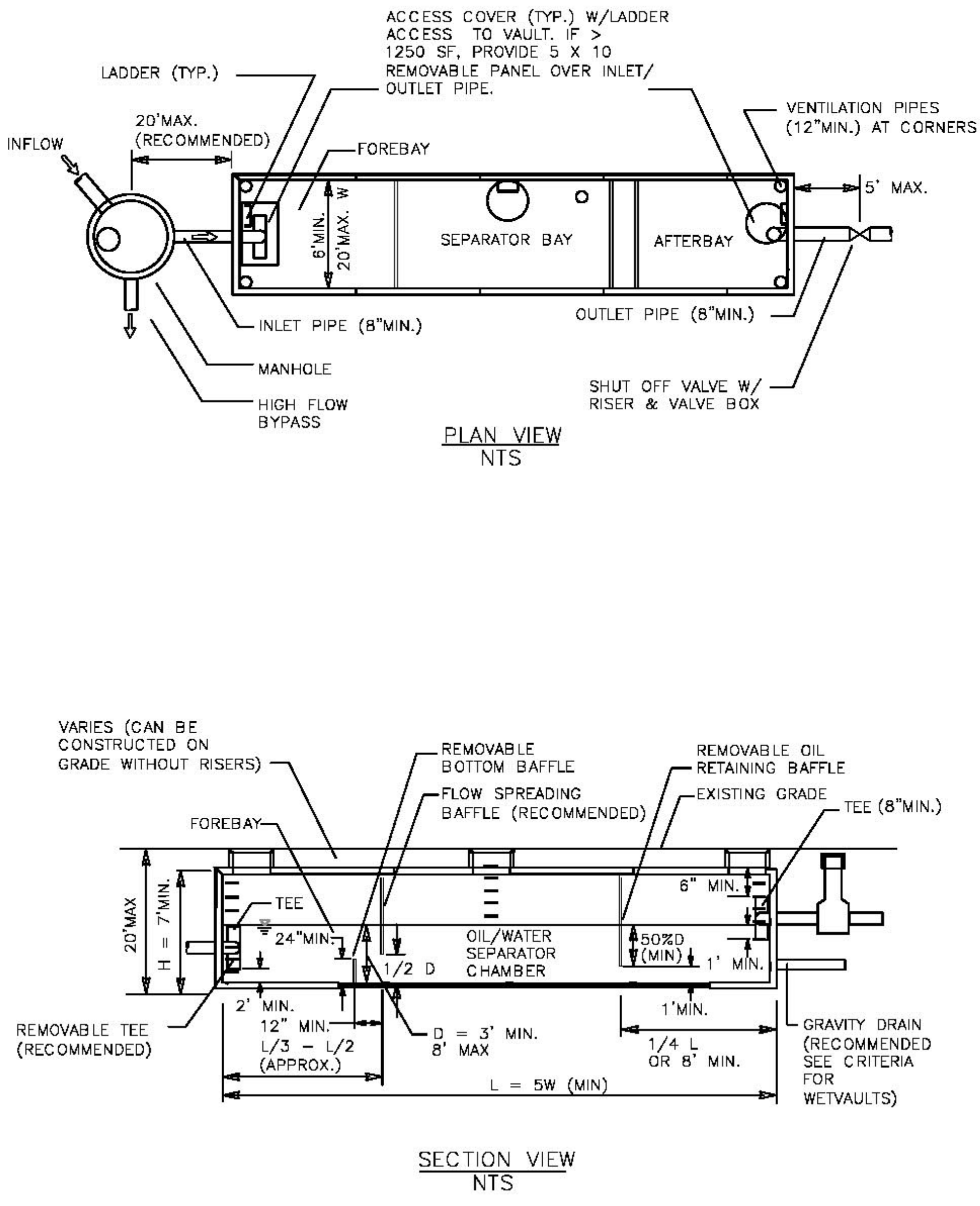


Figure RT.20.1. Baffle-type (API) oil/water separator.

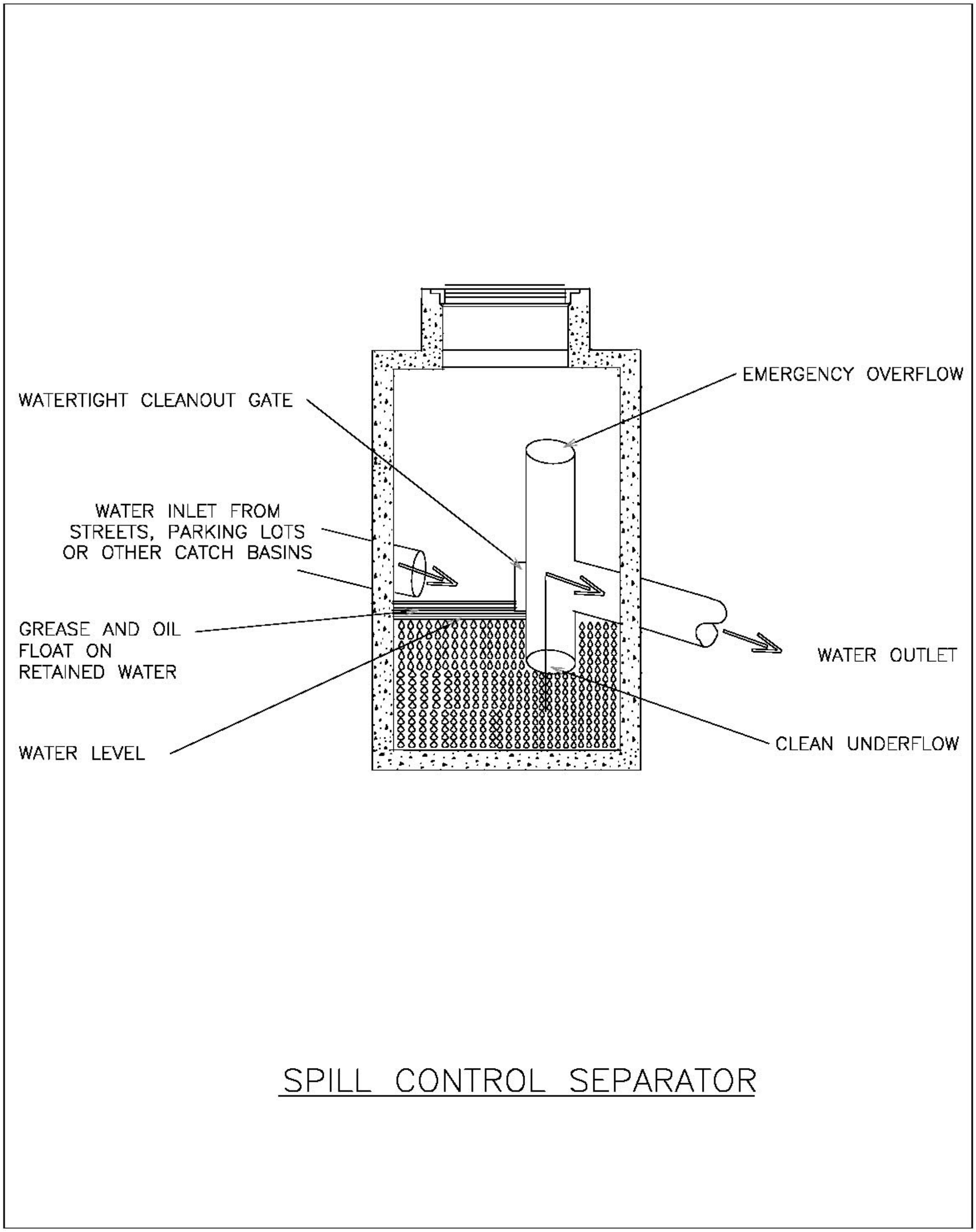


Figure RT.20.2. Spill control separator.

Structural Design Considerations

Details for a typical baffle-type oil/water separator are shown in Figure RT.20.1. Other designs and configurations of separator units and vaults are allowed, including aboveground units. However, they must produce equivalent treatment results and treat equivalent flows as conventional units.

Geometry

Baffle separators are divided into three compartments: a forebay, a separator bay, and an afterbay. The forebay is primarily to trap and collect sediments, encourage plug flow, and reduce turbulence. The separator bay traps and holds oil as it rises from the water column, and it serves as a secondary sediment collection area. The afterbay, a relatively oil-free cell before the outlet, provides a secondary oil separation area and holds oil entrained by high flows.

Forebay/Afterbay

To collect floatables and settleable solids, the surface area of the forebay must be at least 20 square feet per 10,000 square feet of area draining to the separator. The length of the forebay should be one-third to one-half the length of the entire separator. Roughing screens for the forebay or upstream of the separator may be needed to remove debris. Screen openings should be about ¾ inch.

The inlet must be submerged. A tee section may be used to submerge the incoming flow; it must be at least 2 feet from the bottom of the tank and extend above the runoff treatment design water surface. The intent of the submerged inlet is to dissipate the energy of the incoming flow. The minimum 2-foot distance from the bottom is to minimize resuspension of settled sediments. Extending the tee to the surface allows air to escape the flow, thus reducing turbulence. Alternative inlet designs that accomplish these objectives are acceptable.

The vault outlet pipe must be sized to pass the design flow before overflow (using the pipe sizing methods in the WSDOT *Hydraulics Manual*). The vault outlet pipe must be backsloped or have a tee extending 1 foot above and below the runoff treatment design water surface to provide for secondary trapping of oils and floatables in the vault. Note: The invert of the outlet pipe sets the runoff treatment design water surface elevation.

Separator vaults must have a shutoff mechanism on the outlet pipe to prevent oil discharges during maintenance and to serve as an emergency shutoff in case of a spill. A valve box and riser must also be provided according to the design criteria for wet ponds (see BMP RT.12 in the HRM).

Separator vaults must be watertight. Where pipes enter and leave a vault below the runoff treatment design water surface, they must be sealed using a nonporous, nonshrinking grout.

Absorbents and/or skimmers should be used in the afterbay as needed.

Separator Bay

The geometry criteria for small drainages is based on horizontal velocity (V_h), oil rise rate (V_t), residence time, width, depth, and length considerations. A correction factor based on American Petroleum Institute (API) turbulence criteria is applied to increase the length.

Ecology is modifying the API criteria for treating stormwater runoff from small drainage areas (fueling stations, commercial parking lots, etc.) by using the design V_h for the design V_h/V_t ratio rather than the API minimum of $V_h/V_t = 15$. The API criteria appear to be applicable for sites with more than 2 acres of impervious drainage area. Performance verification of this design basis must be obtained during at least one wet season (see Section 5-3.6.2, Category 2: Emerging Technologies, in Chapter 5 of the HRM).

The following is the sizing procedure using modified API criteria:

Determine the oil rise rate, V_t (cm/sec), using Stokes' law (WPCF 1985), empirical determination, or 0.033 ft/min for 60-micron oil droplets. The application of Stokes' law to site-based oil droplet sizes and densities, or empirical rise rate determinations, recognizes the need to consider actual site conditions. In those cases, the design basis would not be the 60-micron droplet size and the 0.033 ft/min rise rate.

Stokes' law equation for rise rate, V_t (cm/sec):

$$V_t = g(\sigma_w - \sigma_o)D^2 / 18\eta_w)$$

where: g = gravitational constant = 981 cm/sec²

D = diameter of the oil droplet (cm) = 60 microns (0.006 cm)

σ_w = density of water at 32°F = 0.999 gm/cc

σ_o = density of petroleum oil at 32°F. Select a conservatively high oil density. For example, if both diesel oil at $\sigma_o = 0.85$ gm/cc and motor oil at $\sigma_o = 0.90$ gm/cc might be present, use $\sigma_o = 0.90$ gm/cc.

η_w = 0.017921 poise (gm/cm-sec) (API 1990)

Use the following separator dimension criteria:

- Separator water depth (d): ≥3≤8 feet (to minimize turbulence) (API 1990; U.S. COE 1994)
- Separator width (w): 6 to 20 feet (WEF & ASCE 1998; King County 1998)
- Depth-to-width ratio (d/w): 0.3 to 0.5 (API 1990)
- Minimum length-to-width ratio of separator vaults: 5

For stormwater inflow from drainages less than 2 acres:

1. Determine V_t and select depth and width of the separator section based on the above criteria.

2. Calculate the minimum residence time (t_m) of flow through the separator at depth d:

$$t_m = d/V_t$$

3. Calculate the horizontal velocity of the bulk fluid, V_h; vertical cross-sectional area, A_v; and actual design V_h/V_t (API 1990; U.S. COE 1994):

$$V_h = Q/dw = Q/A_v \ (V_h \text{ maximum at} < 2.0 \text{ ft/min}) \text{ (API 1990)}$$

where: Q = 2.15 x the runoff treatment design flow rate (ft^3/min) at minimum residence time, t_m

At V_h/V_t determine F, turbulence factor (see Figure RT.20.3). API F factors range from 1.28 to 1.74 (API 1990).

4. Calculate the minimum length of the separator section, l(s), using:

$$l(s) = FQtm/wd = F(Vh/Vt)d$$

$$L = l(f) + l(s) + l(a)$$

$$L = l(t)/3 + l(s) + l(t)/4$$

where: L = total length of 3 bays (ft)

l(f) = length of forebay (ft)

l(a) = length of afterbay (ft)

5. Calculate $V = l(s)wd = FQt_m$, and $A_h = l(s)w$

V = minimum hydraulic design volume (ft^3)
A_h = minimum horizontal area of the separator (ft^2)

For stormwater inflow from drainages greater than 2 acres:

1. Use $V_h = 15\ V_t$ and $d = (Q/2V_h)^{1/2}$ (with d/w = 0.5) and repeat calculation steps 3 through 5.

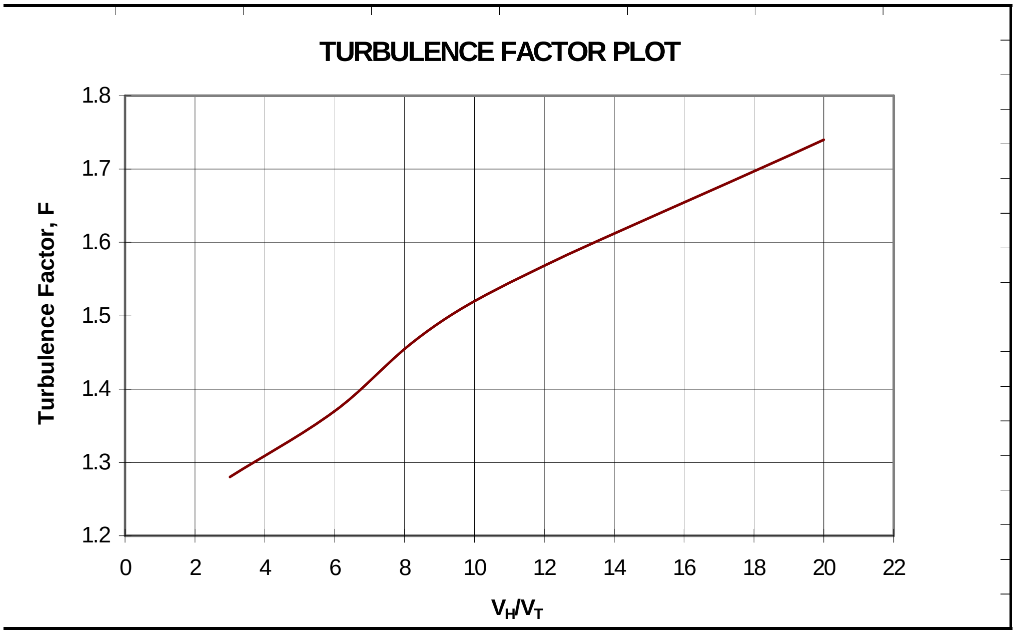


Figure RT.20.3. Turbulence factor plot.

Materials

- Vault material and structural specifications are the same as those for BMP FC.04, Detention Vault.
- All metal parts must be corrosion-resistant. Avoid the use of zinc and galvanized materials (because of their aquatic toxicity potential) when substitutes are available. Painting metal parts for corrosion resistance is not allowed because paint does not provide long-term protection.
- Vault baffles must be made of concrete, stainless steel, fiberglass-reinforced plastic, or other acceptable material, and must be securely fastened to the vault.
- Gate valves, if used, must be designed for seating and unseating heads appropriate for the design conditions.

Berms, Baffles, and Slopes

- A removable flow-spreading baffle, extending downward from the water surface to no more than one-half the vault depth, is recommended to spread flows (see Figure RT.20.1).
- A removable bottom baffle (sediment-retaining baffle) must be provided with a minimum height of 24 inches (see Figure RT.20.1), located at least 1 foot from the oil-retaining baffle. A window wall baffle may be used, but the area of the window opening must be at least three times greater than the area of the inflow pipe.
- A removable oil-retaining baffle must be provided and located approximately ¼ L from the outlet wall or a minimum of 8 feet, whichever is greater (the 8-foot minimum is for maintenance purposes). The oil-retaining baffle must extend

downward from the water surface to a depth of at least 50% of the design water depth, but no closer than 1 foot above the vault bottom (see Figure RT.20.1). Various configurations are possible, but the baffle must be designed to minimize turbulence and entrainment of sediment.

- Baffles may be fixed rather than removable if additional entry ports and ladders are provided to make both sides of the baffle accessible for maintenance.

Site Design Elements

Setback Requirements

Setback requirements for baffle-type oil/water separators are the same as those for detention vaults (see BMP FC.04).

Maintenance Access Roads (Access Requirements)

Access requirements for baffle-type oil/water separators are the same as those for detention vaults (see BMP FC.04), except for the following modifications:

- Access to each compartment is required. If the length or width of any compartment exceeds 50 feet, an additional access point for each 50 feet is required.
- Access points for the forebay and afterbay must be positioned partially over the inlet or outlet tee to allow visual inspection as well as physical access to the bottom of the vault.

Operation and Maintenance

Oil/water separators must be cleaned regularly (see BMP Maintenance Standards for further details) to keep accumulated oil from escaping during storm events.

BMP RT.21 Coalescing Plate Separator

WSDOT does not recognize this BMP as a viable highway application for oil control due to cost and performance considerations associated with maintaining this treatment option. For instructions on seeking approval for using this BMP, refer to Section 5-3.6, Seeking Authorization for Alternative BMP Options, in Chapter 5 of the Highway Runoff Manual.

Introduction

General Description

Coalescing plate oil/water separators typically are manufactured units consisting of a baffled vault containing several inclined corrugated plates stacked and bundled together (see Figure RT.21.1). The plates are equally spaced (typical plate spacing ranges from ¼ to 1 inch) and are made of a variety of materials, the most common being fiberglass and polypropylene. Efficient separation results because the plates reduce the vertical distance oil droplets must rise in order to separate from the stormwater. Once they reach a plate, oil droplets form a film on the plate surface. The film builds up over time until it becomes thick enough to migrate upward under the influence of gravity along the inclined plate. When the film reaches the edge of the plate, oil is released as large droplets, which rise rapidly to the surface where the oil accumulates until it is removed during maintenance activities. Because the plate pack significantly increases treatment effectiveness, coalescing plate separators can achieve a specified treatment level with a smaller vault size than that required for a simple baffle-type oil/water separator. A spill control separator (see Figure RT 20.2) is a simple catch basin with a tee inlet for temporarily trapping small volumes of oil. The spill control separator is included here for comparison only and is not intended to be used for treatment purposes.

Applications and Limitations

Coalescing plate oil/water separators can be used to meet oil control requirements when a site meets the high-use criteria described in Section 5-3.5, Step 3, in Chapter 5 of the HRM. Separators should be used where free oil is expected to be present at treatable high concentrations and sediment will not overwhelm the separator. Coalescing plate separators can be used to meet a performance goal of 10 to 15 milligrams per liter oil concentration by designing the unit to remove oil droplets 60 microns and larger. For low concentrations of oil, other treatment methods (such as sand filters or emerging technologies) may be more applicable.

For inflows from small drainage areas (e.g., fueling stations and maintenance shops), a coalescing plate separator is typically considered due to space limitations. However, if the plates are likely to become plugged, then a new design basis for the baffle-type (API) separator may be considered on an experimental basis (see BMP RT.20).

Oil/water separators are designed to remove free oil and are not generally effective in separating oil that has become either chemically or mechanically emulsified and dissolved in water. Therefore, it is desirable that separators be installed upstream of drainage facilities and conveyance structures that introduce flow turbulence and consequently promote emulsification. Emulsification of oil can also result wherever surfactants or detergents are used to wash vehicles and in parking/maintenance areas that drain to the separator. Detergents should not be used to clean vehicles or in parking/maintenance areas unless the wash water is collected and disposed of properly (usually to the sanitary sewer).

Without intense maintenance, oil/water separators may not be sufficiently effective in removing oil and total petroleum hydrocarbons (TPH) down to desired levels. Excluding runoff from unpaved areas helps to minimize the amount of sediment entering the vault, reducing the need for maintenance. A unit that fails and ceases to function can release previously trapped oil to the downstream receiving water, both from the oily sediments and the entrainment of surface oils.

In moderately pervious soils where seasonal groundwater may induce flotation, buoyancy of the vault structure must be balanced by ballasting or other methods, as appropriate.

Wet vaults may also be modified to function as coalescing plate oil/water separators (see design criteria for wet vaults, BMP RT.19).

Construction of coalescing plate separators should follow and conform to the manufacturer's recommended construction procedures and installation instructions as well as the WSDOT Standard Specifications. Particular care must be taken when inserting coalescing plate packs in the vault so as not to damage or deform the plates. After the separator is installed, it must be thoroughly cleaned and flushed before it begins operating.

Presettling and/or Pretreatment

Pretreatment should be considered if the level of TSS in the inlet flow would cause the coalescing plates to clog or otherwise impair the long-term efficiency of the separator.

Design Flow Elements

Flows to Be Treated

Coalescing plate separators must be designed to treat 2.15 times the runoff treatment design flow (see Section 3-3.5, Minimum Requirement 5, in Chapter 3 of the HRM). Hydrologic methods are presented in Sections 4-3 and 4-4 in Chapter 4 of the HRM.

Flow Splitters

Coalescing plate separators must be installed off-line from the primary drainage system. All flows greater than 2.15 times the runoff treatment design flow must bypass the separator. For flow splitter design guidelines, see Section 5-4.3.4 in Chapter 5 of the HRM.

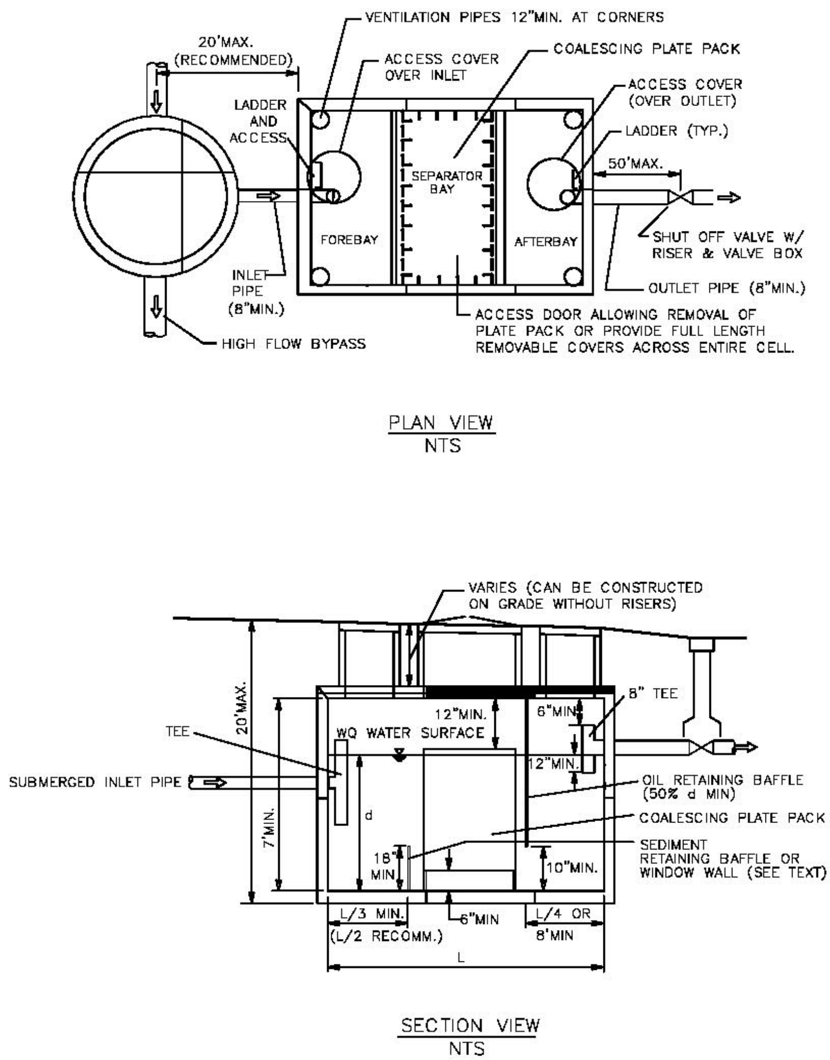


Figure RT.21.1. Coalescing plate separator.

Structural Design Considerations

Details for a typical coalescing plate oil/water separator are shown in Figure RT.21.1. Other designs and configurations of separator units and vaults are allowed, including aboveground units. However, they must produce equivalent treatment results, treat equivalent flows as conventional units, and be submitted to the region WSDOT Hydraulics and Water Quality Program for approval.

Geometry

Coalescing plate separators are divided by baffles or berms into three compartments: a forebay, a separator bay that houses the plate packs, and an afterbay. The forebay controls turbulence and traps and collects debris. The separator bay captures and holds oil. The afterbay provides a relatively oil-free exit cell before the outlet.

Forebay/Afterbay

The length of the forebay must be a minimum of one-third the length of the vault (1/3 *L*), but 1/2 *L* is recommended. In addition, it is recommended that the surface area of the forebay be at least 20 square feet per 10,000 square feet of tributary impervious area draining to the separator. In lieu of an attached forebay, a separate grit chamber, sized to be at least 20 square feet per 10,000 square feet of tributary impervious area, may precede the oil/water separator.

The inlet must be submerged. A tee section may be used to submerge the incoming flow, but it must be at least 2 feet from the bottom of the tank and extend above the runoff treatment design water surface. The intent of the submerged inlet is to dissipate the energy of the incoming flow. The minimum 2-foot distance from the bottom is to minimize resuspension of settled sediments. Extending the tee to the surface allows air to escape the flow, thus reducing turbulence. Alternative inlet designs that accomplish these objectives are acceptable, but must be submitted to the region WSDOT Hydraulics Office and Water Quality Program for approval.

The vault outlet pipe must be sized to pass the design flow before overflow (using the pipe sizing methods in the WSDOT *Hydraulics Manual*). The vault outlet pipe must be backsloped or have a tee extending 1 foot above and below the runoff treatment design water surface to provide for secondary trapping of oils and floatables in the vault. Note that the invert of the outlet pipe sets the runoff treatment design water surface elevation.

Separator vaults must have a shutoff mechanism on the outlet pipe to prevent oil discharges during maintenance and to serve as an emergency shutoff in case of a spill. A valve box and riser must also be provided according to the design criteria for wet ponds (see BMP RT.12 in the HRM).

Separator vaults must be watertight. Where pipes enter and leave a vault below the runoff treatment design water surface, they must be sealed using a nonporous, nonshrinking grout.

Absorbents and/or skimmers should be used in the afterbay, as needed.

Separator Bay

Calculate the projected (horizontal) surface area of plates needed using the following equation:

$$A_p = Q/V_t = Q/0.00386(\sigma_w - \sigma_o/\eta_w)$$
$$A_p = A_a(\text{cosine b})$$

where: Q = 2.15 x the runoff treatment design flow rate (ft^3/min)

V_t = rise rate of 0.033 ft/min, or empirical determination, or Stokes' law-based

A_p = projected surface area of the plate (ft^2); 0.00386 is unit conversion constant

σ_w = density of water at 32° F = 62.4 lb/ft^3

σ_o = density of petroleum oil at 32° F = 51.2 lb/ft^3

A_a = actual plate area (ft^2) (one side only)

b = angle of the plates with the horizontal (deg) (usually varies from 45° to 60°)

η_w = viscosity of water at 32° F = 1.931 x 10^{-5} cfs

- Space plates a minimum of 3/4 inch apart (perpendicular distance between plates) (WEF & ASCE 1998; U.S. COE 1994; U.S.A.F. 1991; Jaisinghani 1979).
- Select a plate angle between 45° to 60° from the horizontal.
- Locate plate pack at least 6 inches from the bottom of the separator to provide for sediment storage.
- Add 12 inches minimum headspace from the top of the plate pack and the bottom of the vault cover.
- Design inlet flow distribution and baffles in the separator bay to minimize turbulence, flow short-circuiting, and channeling of the inflow, especially through and around the plate packs of the separator. The Reynolds number (a dimensionless parameter used to determine laminar to turbulent flow in pipes) through the separator bay should be <500 (laminar flow).
- Design plates for ease of removal and cleaning with high-pressure rinse or equivalent.

Materials

- For vault material and structural specifications, see BMP FC.04.
- All metal parts must be corrosion-resistant. Avoid use of zinc and galvanized materials (because of their aquatic toxicity potential) when substitutes are available. Painting metal parts for corrosion resistance is not allowed because paint does not provide long-term protection.
- Vault baffles must be made of concrete, stainless steel, fiberglass-reinforced plastic, or other acceptable material and must be securely fastened to the vault.
- Gate valves, if used, must be designed for seating and unseating heads appropriate for the design conditions.

- Plate packs must be made of fiberglass, stainless steel, or polypropylene.
- It is recommended that the entire space between the sides of the plate pack and the vault wall be filled with a solid but lightweight removable material, such as a plastic or polyethylene foam, to prevent the flow from short-circuiting around the sides of the plate pack. Rubber flaps are not effective for this purpose.

Berms, Baffles, and Slopes

- A bottom sediment-retaining baffle must be provided upstream of the plate pack. The minimum height of the sludge-retaining baffle must be 18 inches. Window walls may be used, but the window opening must be a minimum of three times greater than the area of the inflow pipe.
- An oil-retaining baffle must be provided. The baffle must be at least 8 feet from the outlet wall for maintenance purposes. For large units, a baffle position of 1/4 L from the outlet wall is recommended. The oil-retaining baffle must extend from the water surface to a depth of at least 50% of the design water depth. Various configurations are possible, but the baffle must be designed to minimize turbulence/entrainment of sediment.

Site Design Elements

Setback Requirements

Setback requirements for coalescing plate oil/water separators are the same as those for detention vaults (see BMP FC.04).

Maintenance Access Roads (Access Requirements)

Access requirements for coalescing plate oil/water separators are the same as those for detention vaults (see BMP FC.04), except for the following modifications:

- Access to each compartment is required. If the length or width of any compartment exceeds 50 feet, an additional access point for each 50 feet is required.
- Access points for the forebay and afterbay must be positioned partially over the inlet or outlet tee to allow visual inspection as well as physical access to the bottom of the vault.
- Access to the compartment containing the plate pack must be via a removable panel that can be opened wide enough to remove the entire coalescing plate pack from the cell for cleaning or replacement. Doors or panels must have stainless steel lifting eyes, and panels must weigh no more than 5 tons per panel.
- A parking area or access pad (25- by 15-foot minimum) must be provided near the coalescing plate oil/water separator structure to allow the plate pack to be removed from the vault by a truck-mounted crane or backhoe and to allow accumulated solids and oils to be extracted from the vault using a Vactor truck.

Operation and Maintenance

Oil/water separators must be cleaned regularly (see BMP Maintenance Standards for further details) to keep accumulated oil from escaping during storm events.

4 Treatment Train Approach

WSDOT does not recognize the treatment train approach for phosphorus or dissolved metals removal as a viable highway application due to cost and performance considerations associated with maintaining these treatment options. For instructions on seeking approval for using these BMPs, refer to Section 5-3.6, Seeking Authorization for Alternative BMP Options, in Chapter 5 of the Highway Runoff Manual.

Table 4.1. Treatment train combinations for phosphorus removal in projects.

First Basic Runoff Treatment Facility	Second Runoff Treatment Facility
RT.04, RT.06 Biofiltration Swale	RT.14, RT.16 Sand Filter Basin or Vault (basic)
RT.02 Vegetated Filter Strip	RT.15 Linear Sand Filter (basic) with no presettling cell needed
RT.15 Linear Sand Filter (basic)	RT.02 Vegetated Filter Strip
RT.12 Wet Pond (basic)	RT.14, RT.16 Sand Filter Basin or Vault (basic)
RT.19 Wet Vault (basic)	RT.14, RT.16 Sand Filter Basin or Vault (basic)
RT.13 Constructed Stormwater Treatment Wetland	RT.14, RT.16 Sand Filter Basin or Vault (basic)
CO.01, CO.03 Combined Wet/Detention Pond or Vault (basic)	RT.14, RT.16 Sand Filter Basin or Vault (basic)

Table 4.2. Treatment train combinations for dissolved metals removal in projects.

First Basic Runoff Treatment Facility	Second Runoff Treatment Facility
RT.04, RT.06 Biofiltration Swale	RT.14, RT.16 Sand Filter Basin or Vault, or RT.18 StormFilter™ [(1)]
RT.02 Vegetated Filter Strip	RT.15 Linear Sand Filter (basic) with no presettling cell needed
RT.15 Linear Sand Filter (basic)	RT.02 Vegetated Filter Strip
RT.12 Wet Pond	RT.14, RT.16 Sand Filter Basin or Vault, or RT.18 StormFilter™ [(1)]
RT.19 Wet Vault (basic)	RT.14, RT.16 Sand Filter Basin or Vault, or RT.18 StormFilter™ [(1)]
CO.01, CO.03 Combined Wet/Detention Pond or Vault (basic)	RT.14, RT.16 Sand Filter Basin or Vault, or RT.18 StormFilter™ [(1)]
RT.14, RT.16 Sand Filter Basin or Vault (basic) with a presettling cell if the filter is not preceded by a detention facility	RT.18 StormFilter™ [(1)]

[(1)] The medium must have the capability to remove dissolved metals effectively based on at least limited data. Ecology includes the StormFilter™ leaf compost and zeolite media in this category.

5 BMP Maintenance Standards

Table 5.1. Maintenance standards for wet vaults.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and debris	Trash and debris have accumulated in vault, pipe, or inlet/outlet (includes floatables and nonfloatables).	No trash or debris remain in vault.
	Sediment accumulation in vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6 inches.	No sediment remains in vault.
	Damaged pipes	Inlet/outlet piping is damaged or broken and in need of repair.	Pipe is repaired and/or replaced.
	Access cover damaged/ not working	Cover cannot be opened or removed by one person.	Cover is repaired or replaced to proper working specifications.
	Ventilation	Ventilation area is blocked or plugged.	Blocking material is removed or cleared from ventilation area. A specified percent of the vault surface area must provide ventilation to the vault interior (see design specifications).
	Vault structure damage: includes cracks in walls or bottom, damage to frame or top slab	Maintenance/inspection personnel determine that the vault is not structurally sound.	Vault is replaced or repairs made so that the vault meets design specifications and is structurally sound.
		Cracks are wider than ½ inch at the joint of any inlet/outlet pipe, or there is evidence of soil particles entering through the cracks.	Vault is repaired so that no cracks are wider than ¼ inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles are corroding, cracking, warping, or showing signs of failure as determined by maintenance/inspection staff.	Baffles are repaired or replaced to specifications.
	Access ladder damage	Ladder is corroded or deteriorated, not functioning properly, not attached to structure wall, missing rungs, has cracks, or is misaligned. Confined-space warning sign is missing.	Ladder is replaced or repaired to specifications and is safe to use, as determined by inspection personnel. Sign warning of confined space entry requirements is in place. Ladder and entry notification comply with WISHA standards.

Table 5.2. Maintenance standards for closed treatment systems (tanks/vaults).

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Storage area	Plugged air vents	One-half of the cross section of a vent is blocked at any point, or the vent is damaged.	Vents are open and functioning.
	Debris and sediment	Accumulated sediment depth exceeds 10% of the diameter of the storage area for ½ length of storage vault, or any point depth exceeds 15% of diameter. (Example: 72-inch storage tank requires cleaning when sediment reaches depth of 7 inches for more than ½ length of tank.)	All sediment and debris are removed from storage area.
	Joints between tank/pipe section	Openings or voids allow material to be transported into facility. (Will require engineering analysis to determine structural stability.)	All joints between tank/pipe sections are sealed.
	Tank/pipe bent out of shape	Any part of tank/pipe is bent out of shape more than 10% of its design shape. (Review required by engineer to determine structural stability.)	Tank/pipe is repaired or replaced to design specifications.
	Vault structure: includes cracks in walls or bottom, damage to frame or top slab	Cracks are wider than ½ inch and there is evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault is replaced or repaired to design specifications and is structurally sound.
		Cracks are wider than ½ inch at the joint of any inlet/outlet pipe, or there is evidence of soil particles entering the vault through the walls.	No cracks are more than ¼ inch wide at the joint of the inlet/outlet pipe.

Table 5.3. Maintenance standards for sand filters (aboveground/open).

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Aboveground (open sand filter)	Sediment accumulation on top layer	Sediment depth exceeds ½ inch.	No sediment deposit is observed on grass layer of sand filter that would impede permeability of the filter section.
	Trash and debris	Trash and debris have accumulated on sand filter bed.	Trash and debris are removed from sand filter bed.
	Sediment/debris in cleanouts	Cleanouts are full or partially plugged with sediment or debris.	Sediment is removed from cleanouts.
	Sand filter media	Drawdown of water through the sand filter media takes longer than 24 hours, or flow through the overflow pipes occurs frequently.	Top several inches of sand are scraped. May require replacement of entire sand filter depth depending on extent of plugging (a sieve analysis is helpful to determine if the lower sand has too high a proportion of fine material).
	Prolonged flows	Sand is saturated for prolonged periods (several weeks) and does not dry out between storms due to continuous base flow or prolonged flows from detention facilities.	Low continuous flows are limited to a small portion of the facility by using a low wooden divider or slightly depressed sand surface.
	Short-circuiting	Flows become concentrated over one section of the sand filter rather than dispersed.	Flow and percolation of water through sand filter are uniform and dispersed across the entire filter area.
	Erosion damage to slopes	Erosion is more than 2 inches deep and potential for continued erosion is evident.	Slopes are stabilized using proper erosion control measures.
	Rock pad missing or out of place	Soil beneath the rock is visible.	Rock pad is replaced or rebuilt to design specifications.
	Flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed across sand filter.	Spreader is leveled and cleaned so that flows are spread evenly over sand filter.
	Damaged pipes	Any part of the piping is crushed or deformed more than 20%, or any other failure to the piping is observed.	Pipe is repaired or replaced.

Table 5.4. Maintenance standards for sand filters (belowground/enclosed).

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Belowground vault	Sediment accumulation on sand media section	Sediment depth exceeds ½ inch.	No sediment deposits are on sand filter section that would impede permeability of the filter section.
	Sediment accumulation in presettling portion of vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6 inches.	No sediment deposits are in first chamber of vault.
	Trash and debris	Trash and debris have accumulated in vault or pipe inlet/outlet (includes floatables and nonfloatables).	Trash and debris are removed from vault and inlet/outlet piping.
	Sediment in drain pipes/cleanouts	Drain pipes or cleanouts are filled with sediment or debris.	Sediment and debris are removed.
	Short-circuiting	Seepage/flow occurs along the vault walls and corners. Sand is eroding near inflow area.	Sand filter media section is relaid and compacted along perimeter of vault to form a semiseal. Erosion protection is added to dissipate force of incoming flow and curtail erosion.
	Damaged pipes	Inlet or outlet piping is damaged or broken and in need of repair.	Pipe is repaired or replaced.
	Access cover damaged/not working	Cover cannot be opened, or cover has corroded/deformed. Maintenance person cannot remove cover using normal lifting pressure.	Cover is repaired to proper working specifications or replaced.
	Ventilation	Ventilation area is blocked or plugged.	Blocking material is removed or cleared from ventilation area. A specified percent of the vault surface area must provide ventilation to the vault interior (see design specifications).
	Vault structure damage: includes cracks in walls or bottom, damage to frame or top slab	Cracks are wider than ½ inch and there is evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault is replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks are wider than ½ inch at the joint of any inlet/outlet pipe, or there is evidence of soil particles entering through the cracks.	Vault is repaired so that no cracks are wider than ¼ inch at the joint of the inlet/outlet pipe.
	Baffles/internal walls	Baffles or walls are corroding, cracking, warping, or showing signs of failure as determined by maintenance/inspection personnel.	Baffles are repaired or replaced to specifications.
	Access ladder damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, has missing rungs, or is cracked or misaligned.	Ladder is replaced or repaired to specifications and is safe to use as determined by inspection personnel.

Table 5.5. Maintenance standards for StormFilter™.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Belowground vault	Sediment accumulation on media	Sediment depth exceeds 0.25 inches.	No sediment deposits are observed that would impede permeability of the media.
	Sediment accumulation in vault	Sediment depth exceeds 6 inches in first chamber.	No sediment deposits are in vault bottom of first chamber.
	Trash and debris	Trash and debris have accumulated on filter bed.	Trash and debris are removed from the filter bed.
	Sediment in drain pipes/cleanouts	Drain pipes or cleanouts are filled with sediment or debris.	Sediment and debris are removed.
	Damaged pipe	Any part of the pipe is crushed or damaged due to corrosion or settlement.	Pipe is repaired or replaced.
	Access cover damaged/not working	Cover cannot be opened; one person cannot open the cover using normal lifting pressure; cover has corroded/deformed.	Cover is repaired to proper working specifications or replaced.
	Vault structure: includes cracks in walls or bottom, damage to frame or top slab	Cracks are wider than ½ inch or there is evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault is replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks are wider than ½ inch at the joint of any inlet/outlet pipe, or there is evidence of soil particles entering through the cracks.	Vault is repaired so that no cracks are wider than ¼ inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles are corroding, cracking, warping, or showing signs of failure as determined by maintenance/inspection personnel.	Baffles are repaired or replaced to specifications.
	Access ladder damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, or is cracked or misaligned.	Ladder is replaced or repaired to meet specifications and is safe to use as determined by inspection personnel.
Belowground cartridge type	Filter media	Drawdown of water through the media takes longer than one hour, or overflow occurs frequently.	Media cartridges are replaced.
	Short-circuiting	Flows do not properly enter filter cartridges.	Filter cartridges are replaced.

Table 5.6. Maintenance standards for baffle oil/water separators (API type).

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Monitoring	Discharge water shows obvious signs of poor water quality.	Effluent discharge from vault should be clear without thick visible sheen.
	Sediment accumulation	Sediment depth in bottom of vault exceeds 6 inches.	No sediment deposits are on vault bottom that would impede flow through the vault and reduce separation efficiency.
	Trash and debris	Trash and debris have accumulated in vault or pipe inlet/outlet (includes floatables and nonfloatables).	Trash and debris are removed from vault and inlet/outlet piping.
	Oil accumulation	Oil accumulations exceed 1 inch at the surface of the water.	Extract oil from vault by vactoring. Dispose in accordance with state and local rules and regulations.
	Damaged pipes	Inlet or outlet piping is damaged or broken and in need of repair.	Pipe is repaired or replaced.
	Access cover damaged/not working	Cover cannot be opened, or cover is corroded/deformed.	Cover is repaired to proper working specifications or replaced.
	Vault structure damage: includes cracks in walls or bottom, damage to frame or top slab (see Table 5.5.5 in the HRM for further information on structure damage and fractures or cracks)	Cracks are wider than ½ inch and there is evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault is replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks are wider than ½ inch at the joint of any inlet/outlet pipe, or there is evidence of soil particles entering through the cracks.	Vault is repaired so that no cracks are wider than ¼ inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles are corroding, cracking, warping, or showing signs of failure as determined by maintenance/inspection personnel.	Baffles are repaired or replaced to specifications.
	Access ladder damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, has missing rungs, or is cracked or misaligned.	Ladder is replaced or repaired to specifications and is safe to use as determined by inspection personnel.

Table 5.7. Maintenance standards for coalescing plate oil/water separators.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Monitoring	Discharge water shows obvious signs of poor water quality.	Effluent discharge from vault is clear with no thick visible sheen.
	Sediment accumulation	Sediment depth in bottom of vault exceeds 6 inches, or signs of sediment are visible on plates.	No sediment deposits are on vault bottom and plate media that would impede flow through the vault and reduce separation efficiency.
	Trash and debris	Trash and debris have accumulated in vault or pipe inlet/outlet (includes floatables and nonfloatables).	Trash and debris are removed from vault and inlet/outlet piping.
	Oil accumulation	Oil accumulation exceeds 1 inch at the water surface.	Oil is extracted from vault using vactoring methods. Coalescing plates are cleaned by thoroughly rinsing and flushing. No visible oil is on water.
	Damaged coalescing plates	Plate media broken, deformed, cracked, or showing signs of failure.	A portion of the media pack or the entire plate pack is replaced depending on severity of failure.
	Damaged pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe is repaired and or replaced.
	Baffles	Baffles are corroding, cracking, warping, or showing signs of failure as determined by maintenance/inspection personnel.	Baffles are repaired or replaced to specifications.
	Vault structure damage: includes cracks in walls or bottom, damage to frame or top slab	Cracks are wider than ½ inch and there is evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault is replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks are wider than ½ inch at the joint of any inlet/outlet pipe or there is evidence of soil particles entering through the cracks.	Vault is repaired so that no cracks are wider than ¼ inch at the joint of the inlet/outlet pipe.
	Access ladder damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, has missing rungs, or is cracked or misaligned.	Ladder is replaced or repaired to specifications and is safe to use as determined by inspection personnel.